MACHINERY'S REFERENCE SERIES

EACH NUMBER IS A UNIT IN A SERIES ON ELECTRICAL AND STEAM ENGINEERING DRAWING AND MACHINE DESIGN AND SHOP PRACTICE

NUMBER 99

AUTOMATIC SCREW MACHINE PRACTICE

PART I

OPERATION OF THE BROWN & SHARPE AUTOMATIC SCREW MACHINES

By DOUGLAS T. HAMILTON

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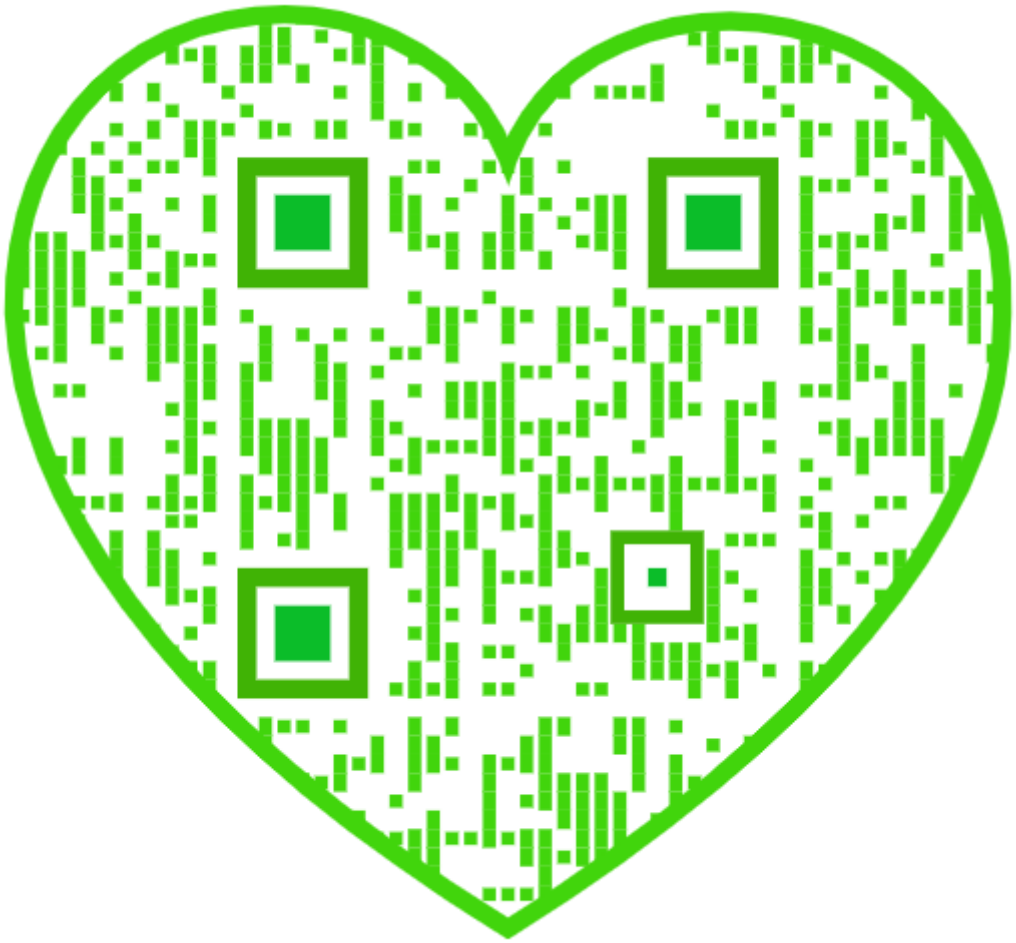

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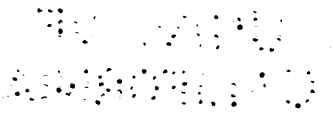
Automatic Screw Machine Practice for the Brown & Sharpe automatic screw machines is covered in eight Reference Books, Nos. 99 to 106, inclusive. Reference Book No. 99, "Operation of the Brown & Sharpe Automatic Screw Machines," deals with the construction of these machines and the setting-up of the tools. No. 100, "Designing and Cutting Cams for Automatic Screw Machines," gives detailed instruction on cam design, and describes a simplified method for milling cams. No. 101, "Circular Form and Cut-off Tools for the Automatic Screw Machine," deals with the general arrangement and the calculations of these tools, and describes the different methods employed in their making. No. 102, "External Cutting Tools for the Automatic Screw Machine," deals with the design and construction of box-tools, taper turning tools, hollow mills, and shaving tools. No. 103, "Internal Cutting Tools for the Automatic Screw Machine," deals with centering tools, cross-slide drilling attachments, counterbores, reamers, and recessing tools. No. 104, "Threading Operations on the Automatic Screw Machine," treats on cam design for threading operations, threading dies, taps and tap drills, die and tap holders, and thread rolling. No. 105, "Knurling Operations on the Automatic Screw Machine," describes the construction of knurling holders, and gives directions for the making of knurls and the design of tools and cams used in connection with knurling operations. No. 106, "Milling, Cross-drilling and Burring Operations on the Automatic Screw Machine," describes screw-slotting attachments, index drilling attachments, and burring attachments, giving directions for their use and for the design of cams for them.



CHAPTER I

CONSTRUCTION OF THE BROWN & SHARPE AUTOMATIC SCREW MACHINES

The object of this treatise is to give the operator a clear idea of the construction of the Brown & Sharpe automatic screw machines, so as to enable him to operate these machines to the best advantage. The various mechanisms, together with their functions and operation, will be dealt with in detail, and the procedure to follow in setting the tools held in the turret and on the cross-slide will be illustrated and described. The No. 00 Brown & Sharpe automatic screw machine, front, rear and plan views of which are shown in Figs. 1, 2 and 3, is made the main subject of this treatise, but wherever the Nos. 0 and 2 machines differ in construction, these differences will be explained. A brief description of the principal features of automatic turret forming and cutting-off machines will also be included, together with tabular and other data of value to the operator.

Principles of Operation

Before proceeding with the description of the construction of the Brown & Sharpe automatic screw machines, the general principles of operation will be briefly outlined. The work spindle is driven from the overhead works by friction pulleys *A* and *B*, see Figs. 1 and 2, by open and cross belts, thus providing for the rotation of the work in either direction. The other operating mechanisms receive their motion from the driving shaft O_3 at the rear (see Fig. 7), which is driven by pulley *C* from the over-head works. The driving shaft carries all the clutches and tripping mechanisms for starting the machine, indexing the turret, reversing the spindle, feeding the stock, and opening and closing the collet, and also drives the front camshaft *D*, and the lead camshaft through a worm and worm-wheel and spur and bevel gearing.

The camshafts, which carry plate cams for operating the front and rear cross-slides *E* and *F* and turret slide *G*, are driven at the required speed for the different jobs by means of change gears *H*. A set of plate cams is made up for each job; the cams are held on the shafts in their correct relation to each other by means of locating pins. The turret *I*, which carries the end-working tools, is provided with six holes, and is indexed by means of tripping levers operated by adjustable dogs held on drum *J*. Drum *K* carries dogs for operating the collet opening and closing and feeding mechanisms. The spindle is reversed when cutting a thread by adjustable dogs held on drum *L*, which can be detached from camshaft *D* by separating coupling *M*. The length of feed is controlled by rotating crank *N*; turning it to the right increases the length of feed, and turning it to the left shortens

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it. The machine is started and stopped by throwing the clutch *O* in or out by means of handle *P*. When the bar is exhausted a bell *R* is rung to notify the operator.

Construction of the Spindle

The spindle A_1, see Fig. 4, runs in phosphor-bronze bearings B_1 and C_1. The front bearing B_1 is split and tapered, and is adjusted by means of nuts D_1 and E_1, in case of wear. A brass liner is placed in the slot in the bearing, and when the latter is worn, this liner should be removed, reduced to the required thickness, and replaced. When the liner is replaced, nut D_1 should be tightened. This bearing is also pro-

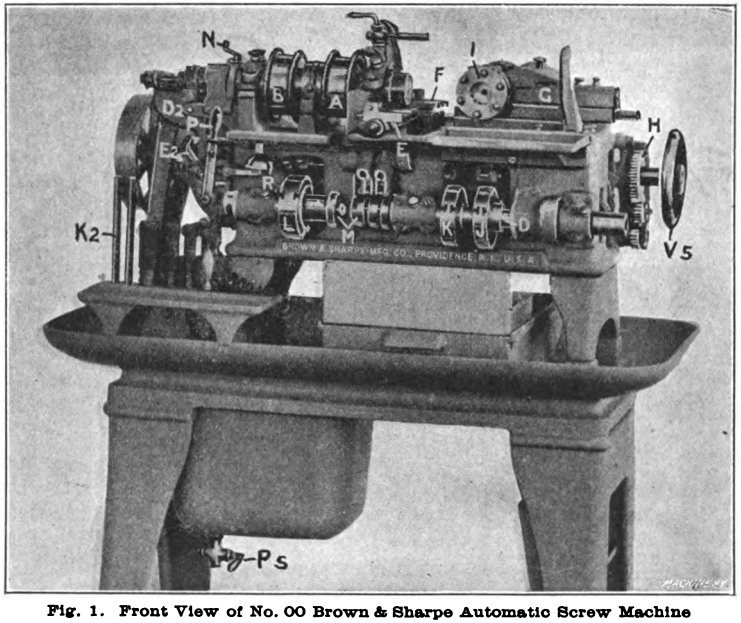


Fig. 1. Front View of No. 00 Brown & Sharpe Automatic Screw Machine

vided with saw slots around its circumference, in which strips of wood are inserted, so that the bearing will have more flexibility and yield more easily to the adjusting nuts.

The rear bearing C_1 is made straight, and is held in the box by nuts F_1 and G_1. The thrust is taken at the rear of the spindle, the thrust bearing consisting of a hardened steel washer H_1 and a bronze washer I_1. Washer H_1 is held against a shoulder on the end of the spindle by nut G_1 and loose washer I_1, the latter running against the hardened and ground inside face of nut G_1. To take up the end play of the spindle, loosen nut F_1 and tighten nut G_1, locking them in place again after adjusting.

The pulleys *A* and *B* which drive spindle A_1 through friction clutch *S*, are driven by open and cross belts from the countershafting. The pulleys rotate freely on the spindle, being provided with steel bushings

J_1 and rollers K_1 which are held in bronze cages L_1. The rollers run on the hardened and ground part of the spindle. The pulleys are oiled from oil reservoirs, the latter being filled by removing screws M_1. Any good machine oil is suitable for oiling these pulleys.

Friction Clutches

The friction clutch body S is tapered to an angle of 12 degrees at each end, and comes in contact with the driving pulleys A or B, when shifted in either the one or the other direction. It is made from phosphor-bronze, turned cone-shaped on each end, and slotted to hold clutch levers N_1, which are made from double-shear steel. These clutch levers are held in the clutch body by screws, and are fulcrumed in notches cut in the spindle. The clutch sleeve O_1 which operates on these levers

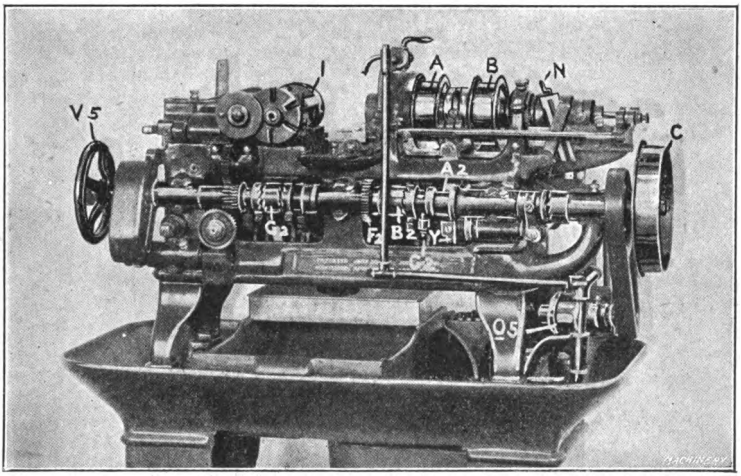


Fig. 2. Rear View of No. 00 Brown & Sharpe Automatic Screw Machine

is slotted to hold hardened steel shoes P_1 which bear on the hardened ends of the clutch levers.

The coned ends of the clutch body are forced into the pulleys by sliding sleeve O_1 over levers N_1. When sleeve O_1 is forced to the right it depresses the right-hand end of levers N_1, and as the lower portion of these levers are fulcrumed in the spindle, which cannot move longitudinally, it is evident that this action must move the clutch body, because the levers are held to it by screws. When the sleeve O_1 is forced in the opposite direction, the same action takes place, the cone-end of the clutch body engaging with the pulley to the left. To adjust the clutches to provide for wear, pulleys A and B are moved in towards the cones of the clutch body by loosening set-screws Q_1 and adjusting the nuts R_1.

The clutch sleeve O_1 is set central by means of screws T, Fig. 3. In making this adjustment a slight play should be allowed in the clutch fork U to avoid friction, except at the point of reversal. Care should also be taken not to run in the screws V too far into the clutch ring W,

so as to split it. This clutch is made in halves and held together by pins.

On the No. 00 machine, the spindle is reversed to run backwards by means of the spring plunger *Y*, Fig. 2, and on the Nos. 0 and 2 machines by the cam A_2. The spring plunger on the No. 00 machine, when released, instantly engages the cone of the clutch with the pulley nearest the collet, and rotates the spindle backwards. To run forward, the clutch is operated by the cam A_2 to engage pulley *B*. Cam A_2, in turn, is operated by clutch B_2, and is released by lever C_2, one revolution of the driving shaft being required for the No. 00, and ½ revolution for the Nos. 0 and 2 machines. Lever C_2, again, is operated by a dog held on drum *L* on the front camshaft, see Figs. 1 and 6.

Operation of the Spring Collet

The spring collet S_1, Fig. 4, which holds the work, is held in sleeve T_1 in the front end of the spindle. This sleeve is driven by a pin in

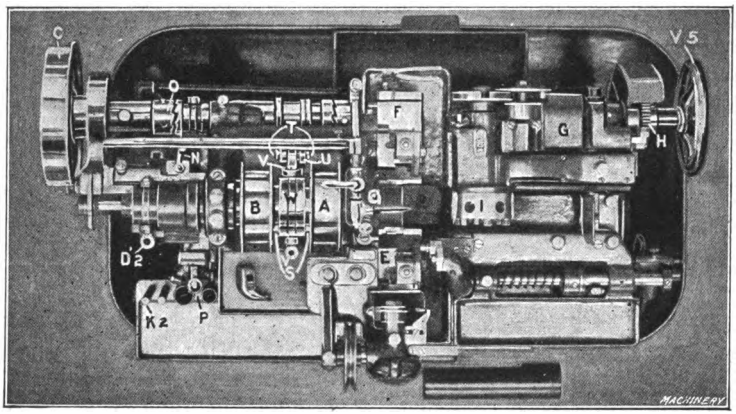


Fig. 3. Plan View of No. 00 Brown & Sharpe Automatic Screw Machine

the spindle, which fits in a slot cut in the sleeve. The front end of the sleeve is ground tapered and fits over the collet S_1. The collet has no end play, being held tightly against the inside ground face of the cap U_1, thus insuring accurate feeding of the stock regardless of any slight variation in size. Spring collet S_1 is closed by means of sleeve T_1, which slides over it and is operated by tube V_1. This tube, on the Nos. 00 and 0 machines, extends through the spindle to the levers W_1, which, in turn, are acted upon by sleeve *Y* through lever D_2 and cam E_2, Figs. 1 and 6.

The collet closing and stock feeding mechanism are operated by the same cam E_2 (on the Nos. 00 and 0 machines), which is driven through spur gears F_2 and positive clutch G_2, Figs. 2 and 7. Clutch G_2 is engaged by depressing lever H_2 by a dog held on drum *K* (see Figs. 1 and 6). The driving shaft makes one revolution, whereupon the clutch is disengaged by the pin lever H_2, Fig. 7, acting upon the cam surface of the clutch, returning it to its original position—out of mesh.

To adjust spring collet S_1, Fig. 4, loosen nut I_2 and turn nut J_2 until the holding capacity of the clutch is properly regulated; then re-tighten nut I_2 and lock both nuts by means of the spanner wrenches provided for this purpose. Great care should be exercised in adjusting these nuts. If they are so adjusted that the collet S_1 bears too tightly on the work, either the collet or closing levers W_1 will be broken. A good

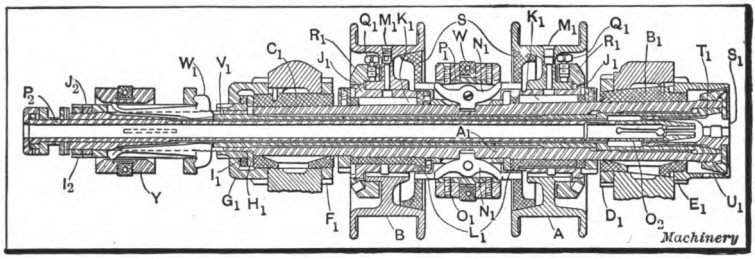


Fig. 4. Section through Spindle, Boxes, Pulleys, etc., of the No. 00 Brown & Sharpe Automatic Screw Machine

method to follow in regulating the proper grip of the collet upon the work is to adjust nuts I_2 and J_2, and then test the grip of the collet by operating fork D_2 by means of the handle K_2 (see Figs. 1 and 3). In this way the proper grip can be secured without difficulty.

On the No. 2 machine the sleeve T_1 (see Fig. 5) is forced over the collet S_1 directly by the levers W_1, the latter being operated by sleeve Y_1 and a cam on the intermediate shaft directly under the spindle.

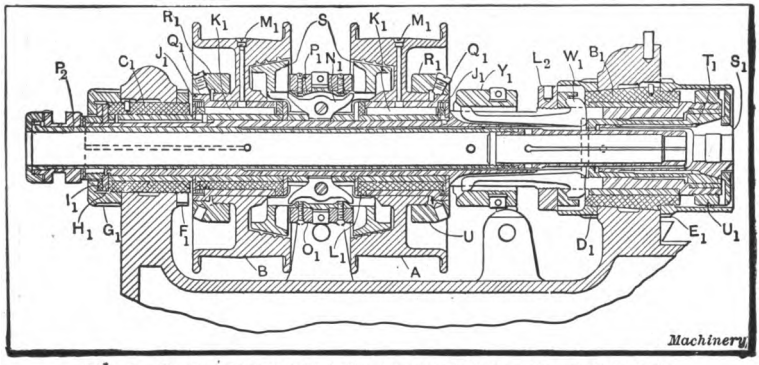


Fig. 5. Section through Spindle, Boxes, Pulleys, etc., of the No. 2 Brown & Sharpe Automatic Screw Machine

To adjust the grip of the collet on the stock, loosen the clamp screw in nut L_2, and turn the knurled nut toward the front of the machine to tighten the collet, reversing the direction of the nut to loosen it.

Operation of the Feeding Mechanism

The feeding mechanism derives its motion from pulley C through spur gear F_2 (Fig. 2) to gear M_2 on central shaft N_2 (Fig. 10). Pulley C is engaged by a positive clutch O (Fig. 7), which is brought into action by means of the starting lever P; in this way the feed is always

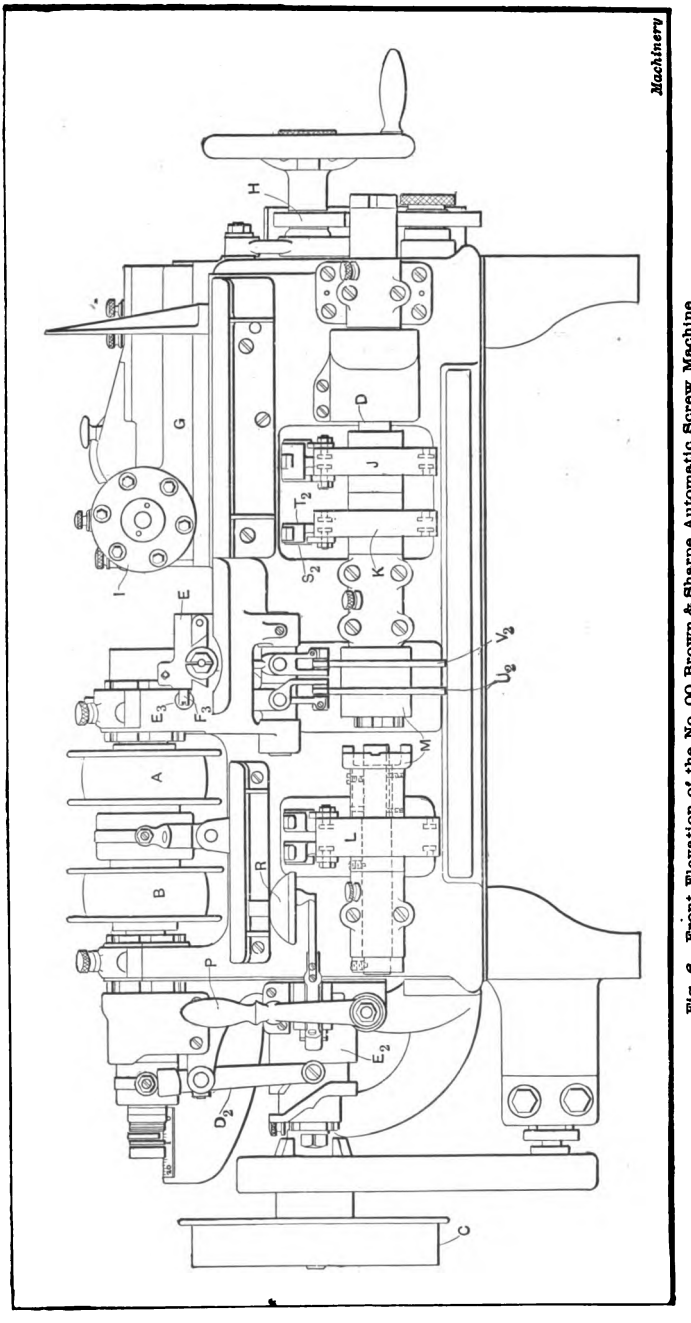


Fig. 6. Front Elevation of the No. 00 Brown & Sharpe Automatic Screw Machine

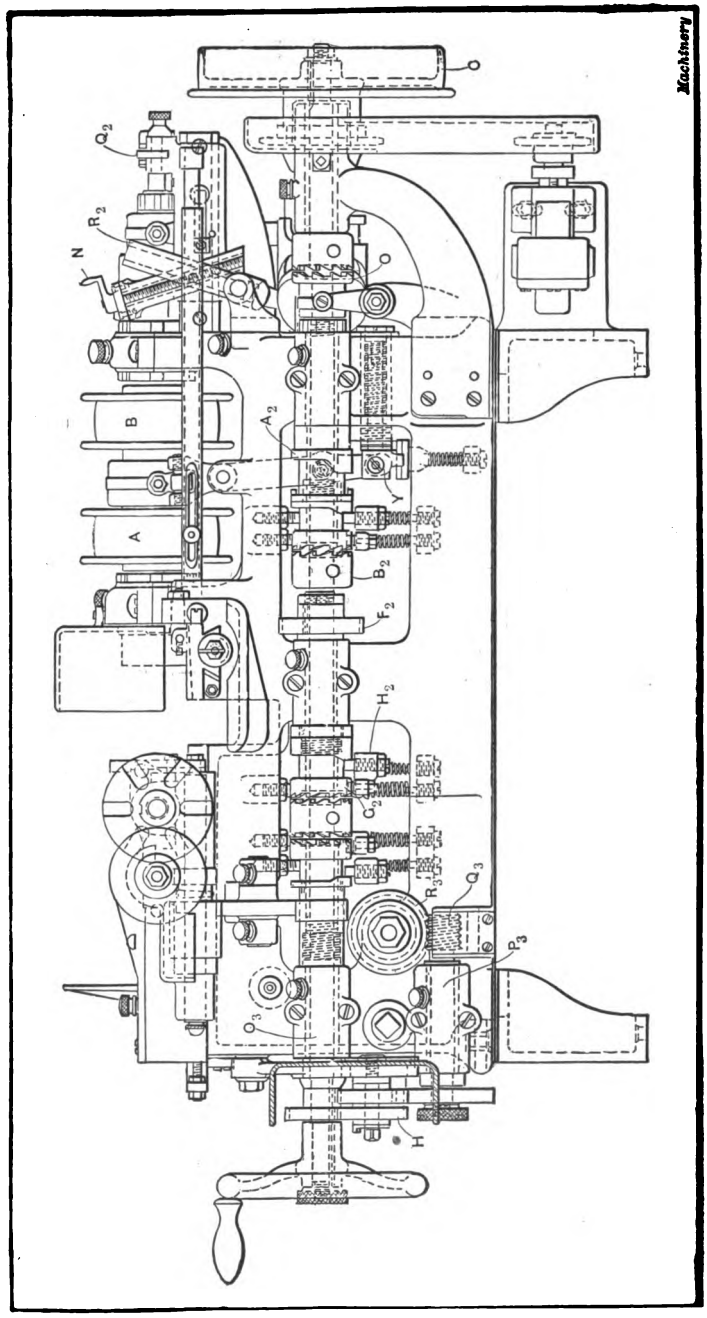


Fig. 7. Rear Elevation of the No. 00 Brown & Sharpe Automatic Screw Machine

under complete control. The stock is fed out by means of a feed finger O_2 (Fig. 4), which is provided with a left-hand thread, and is screwed into the feed tube P_2, the latter passing completely through the spindle. The outer end of the feed tube is connected to the feeding mechanism or slide by means of a latch Q_2, Figs. 7 and 8. The feed slide carrying the latch has a slot cut in it, in which is a sliding block connected to arm R_2, the latter being operated by cam E_2. The sliding block is adjusted in the feed lever by means of a screw and crank N, and as the arm R_2 always moves a fixed distance, the length

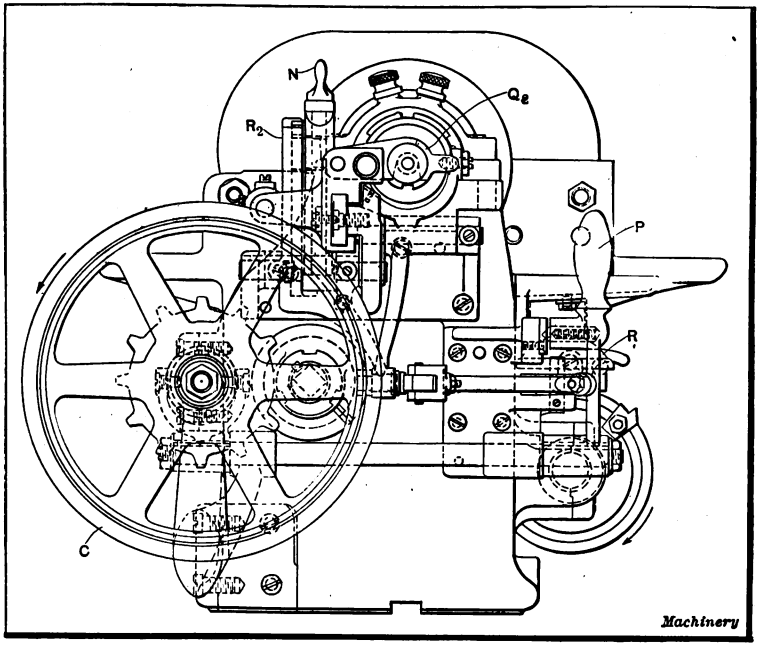


Fig. 8. End Elevation of the No. 00 Machine showing Collet Operating Mechanism

of the feed is obtained by varying the position of the block. A graduated scale which indicates the length to which the stock is fed, is mounted on the feed slide.

When it is desired to change the feeding finger, the feed tube can be withdrawn by lifting the latch. The feeding of the stock can be discontinued by turning up dog S_2, Fig. 6, attached to lever T_2, thus allowing the trip dogs on the drum K to pass by without raising the lever. When it is desired to feed stock more than the usual capacity of the machine, two or more dogs can be placed on the left side of the drum, and the feeding mechanism operated several times.

Operation of the Cross-slides

The front and rear cross-slides E and F are operated by plate cams U_2 and V_2 held on the front camshaft D, Figs. 6 and 9. The front

cross-slide is operated by a direct lever or segment gear W_2 that has teeth cut in its upper end meshing in a rack Y_2, which, in turn, fits in a slot in the base of the cross-slide. This rack is threaded on one end and is provided with a split adjusting nut A_3 which is used for changing the position of the cross-slide relative to the center of the spindle. The screw binding these nuts should always be tightened after the cross-slide has been set to travel the required distance. The rear cross-slide is fitted up in the same manner, but is operafed through an intermediate lever or segment gear B_3 to reverse the motion, thus bringing the cams for operating both slides in a convenient position.

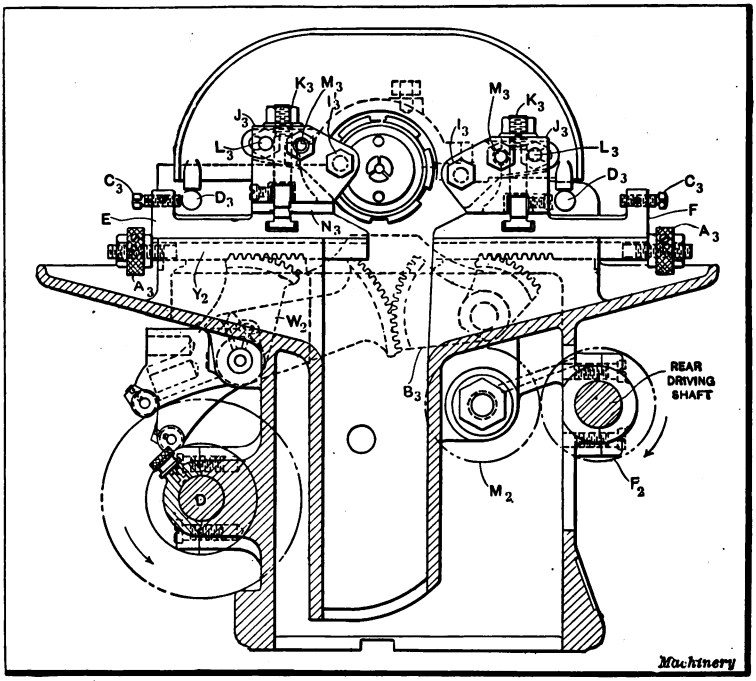


Fig. 9. Partial Section of No. OO Machine showing Operation of Cross-slides

The cross-slides are made to travel to exactly the same point by set-screw C_3 which comes in contact with stop D_3. The cross-slides E and F are returned to their "back" position by means of coil springs and plungers E_3, the latter coming in contact with plugs F_3 screwed into the cross-slides. When setting the circular form and cut-off tools, the slides can be operated by hand by means of a rod inserted into holes provided for that purpose in the ends of the slide-operating segment gears.

The cross-slide tools are circular in form, and are held by screws I_3 to the toolposts J_3, the latter being retained on the cross-slides by T-bolts and nuts K_3. Eccentric nuts are provided on the screws L_3 at the rear of the toolpost, which make it possible to easily and quickly

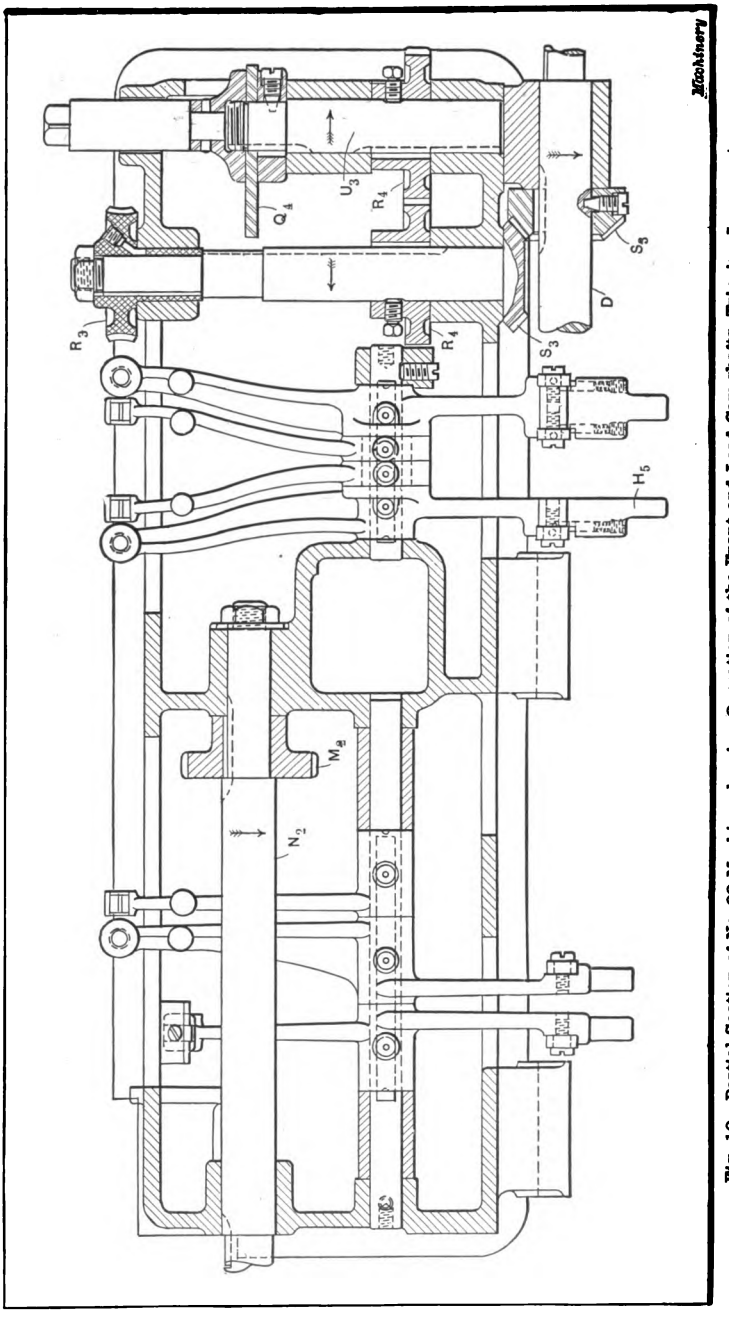


Fig. 10. Partial Section of No. 00 Machine showing Operation of the Front and Lead Cam-shafts, Tripping Levers, etc.

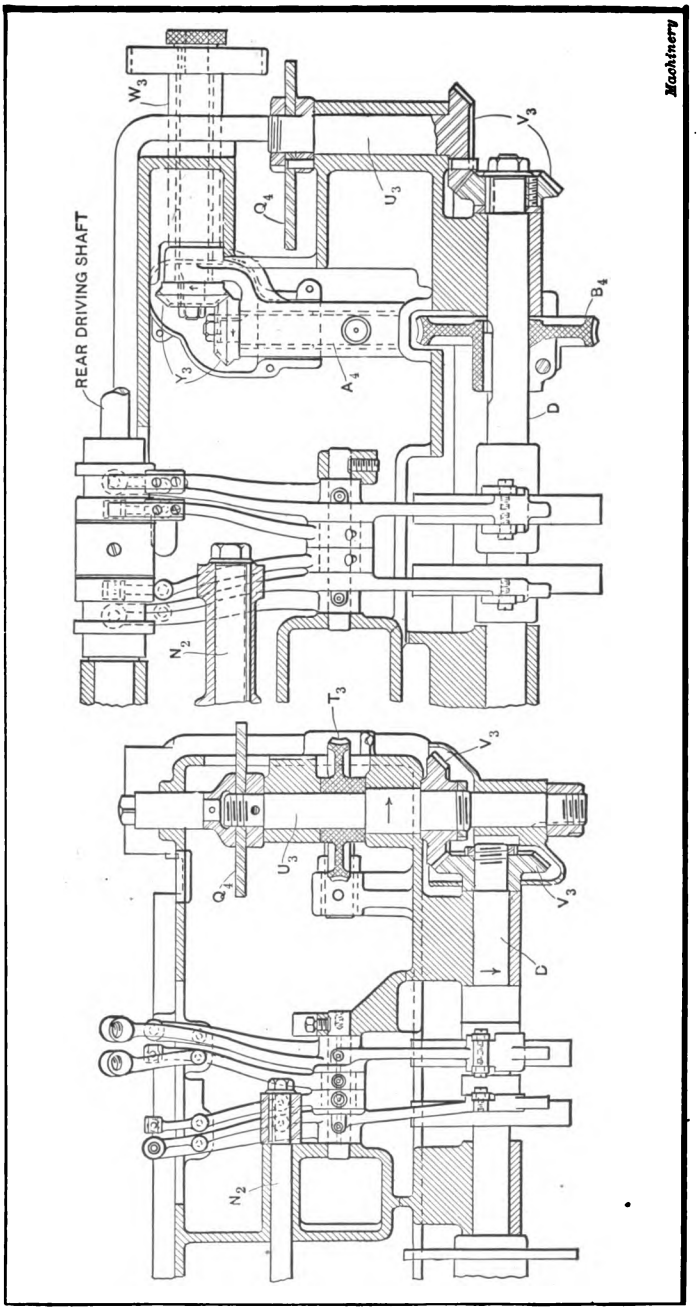


Fig. 12. Partial Section showing how the Front and Lead Camshafts are operated on the No. 2 Machine

Fig. 11. Partial Section showing how the Front and Lead Camshafts are operated on the No. 0 Machine

adjust the circular tools to the proper height. Additional clamping means for the circular tools are provided for by hook-bolts and nuts M_3. The circular tools are ground on the face for sharpening without changing their outline. The block N_3 is provided for raising or lowering the toolposts, so that the circular tools can be ground below center to give sufficient rake.

The manner in which the front camshaft is driven is illustrated in Figs. 7 and 10. Power is transmitted from the rear driving shaft O_3

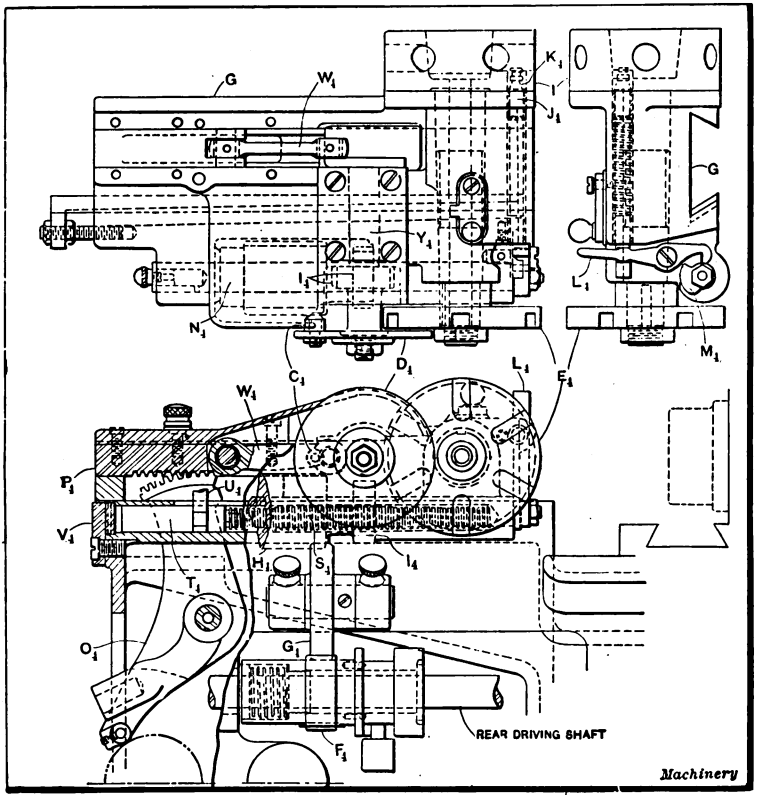


Fig. 13. Plan and Rear Elevation of No. 00 Machine showing Operation of Turret Slide, etc.

through the change gearing H to the worm-shaft P_3. Double-pitch worm Q_3 drives worm-wheel R_3, which through bevel gears S_3 rotates front camshaft D. On the Nos. 0 and 2 machines, the power is transmitted differently as can be seen in Figs. 11 and 12. On the No. 0 machine the power is transmitted from the rear driving shaft through the change gearing to a single-pitch worm, the latter driving the worm-wheel T_3 on the lead camshaft U_3, which furnishes power to the camshaft D through bevel gears V_3. The arrangement is slightly different on the No. 2 machine. The power in this case comes from the

rear driving shaft through the change gearing to the so-called "worm-shaft" W_3, which through bevel gears Y_3 drives the single-pitch worm on shaft A_4 and the worm-wheel B_4 on front cam-shaft D.

Operation of the Turret Slide

The turret I, Fig. 13, which holds the working tools, is mounted vertically on the side of the turret slide G. The turret has a long tapered shank which forms the bearing in the turret slide. It is rotated by means of a hardened roll C_4 on a disk D_4, which engages in radial grooves in the disk E_4. Disk D_4 is driven from the rear driving shaft through spur gears F_4, G_4, and H_4, and helical gears I_4. There are six

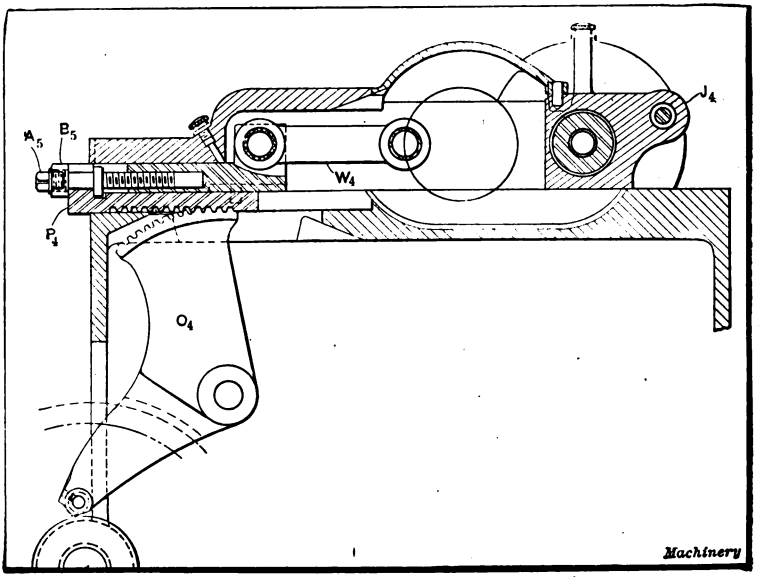


Fig. 14. Partial Section of No. 2 Machine showing Operation of Turret Slide

holes in the turret, disk D_4 making six revolutions for every complete revolution of the turret. The turret is locked in position by the hardened tapered plug J_4 which fits in a hardened bushing K_4 in the turret. This plug is operated by a trip latch L_4, which is withdrawn by a cam M_4 on one end of the shaft N_4. The locking pin or plug is withdrawn from the turret by hand by pushing back latch L_4.

Slide G upon which the turret I is mounted receives its forward movement from the lead cam Q_4 (Fig. 10) through the bell crank lever O_4 and rack block P_4. The lead camshaft (Fig. 10) is driven from the rear driving shaft through worm-wheel R_3 and spur gears R_4. The turret slide is returned by a coil spring S_4, plunger T_4 and pin U_4, shown in Fig. 13, the plunger is located in its "back" position by a stop-block V_4.

The quick return and advance of the turret slide and the revolving of the turret are controlled independently of the lead cam by the crank

W_4, which is connected eccentrically to the turret revolving shaft Y_4. This crank indexes the turret while the roll on the bell crank lever O_4 is passing from the highest point of the lead cam to the starting point of the lobe for the next cut. Crank W_4 is driven from the rear driving shaft, as previously described, by a positive clutch, the latter being operated by tripping levers and dogs on drum J, Fig. 6.

As the crank revolves it allows spring S_4, Fig. 13, to return the turret slide. The turret is then revolved, as described, and when the crank comes to rest after making one complete revolution, the machine is

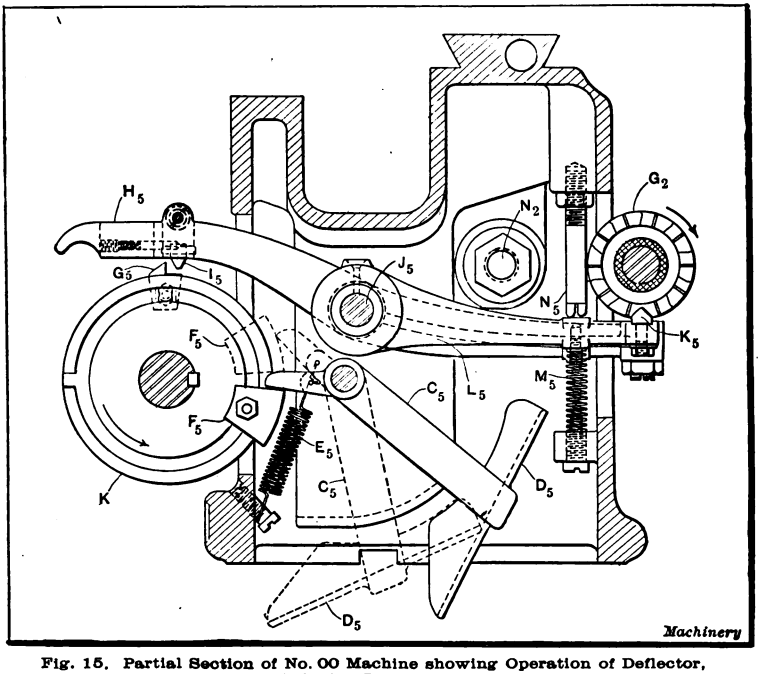


Fig. 15. Partial Section of No. 00 Machine showing Operation of Deflector, Tripping Levers, etc.

ready for the next operation. The bell crank lever O_4 bears against the bed at the extreme forward movement and insures the positive return of the turret slide should the spring fail, owing to the binding of the turret tools on the work. The turret slide is not adjustable lengthwise on the Nos. 00 and 0, but on the No. 2 machine an adjustment of 1 inch is provided for by a screw A_5 and lock nut B_5, Fig. 14.

On the No. 0 machine the indexing disk D_4, Fig. 13, is driven as before described from the rear driving shaft through spur gears, but the turret revolving shaft Y_4 receives its motion from shaft N_4 through bevel gears. The lead camshaft U_3 is driven from front camshaft D through bevel gears V_3.

The indexing disk D_4 on the No. 2 machine (see Fig. 13) is driven in a manner similar to that of the No. 0 machine, but in this case D_4

is a spur gear. The latch L_4 on the No. 0 and 2 machines is operated by a cam on indexing disk D_4. The lead camshaft U_3 is driven from the front camshaft D through bevel gears V_3, as shown in Fig. 12.

Operation of the Deflector

To separate the chips and oil from the work which is cut off, a deflector is provided, as shown in Fig. 15. This deflector consists of a bell-crank C_5 to which a pan or chute D_5 is integrally cast. The crank is operated by spring E_5 and cam block F_5 on drum K, which lifts up the forward end of the crank, moving the deflector into the position shown by the dotted lines. This brings it directly under the fixed

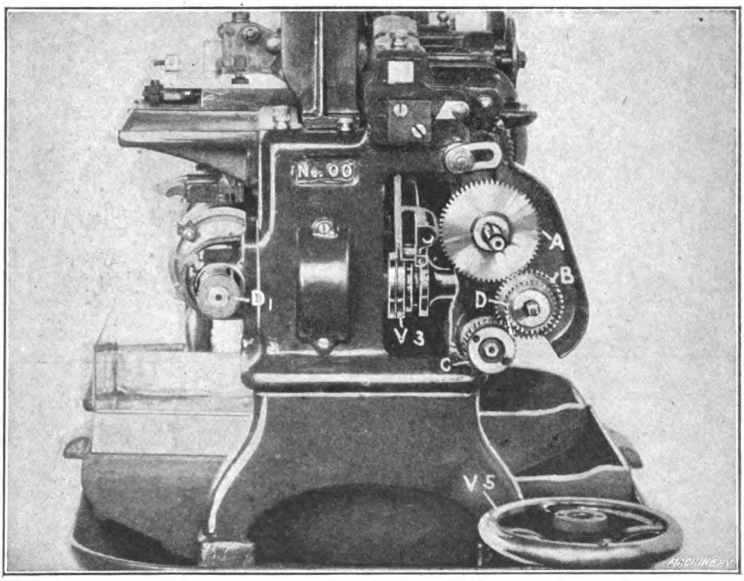


Fig. 16. End View of No. 00 Machine showing Arrangement of Change Gears

chute of the machine, so that the work is deflected from the pan for the chips into the pan provided for holding the work. The cam block is adjustably mounted on the drum so that it can be moved into the desired position for operating the deflector. On work requiring a small amount of machining, the deflector must remain under the chute for a longer period than is required on longer operations; therefore, cam blocks having different lengths of arcs are provided, to allow the deflector to remain under the chute for a greater or less time.

Fig. 15 illustrates clearly the construction and action of the tripping lever for operating clutch G_2, Fig. 2. The operation is as follows: A dog G_5 on drum K lifts tripping lever H_5 by means of the block I_5, and as H_5 is fulcrumed on shaft J_5, this action lowers the rear end of the lever. A pin held in the rear end of the lever by adjusting nuts, fits in a recess in the cam which forms one jaw of the clutch G_2, and as the

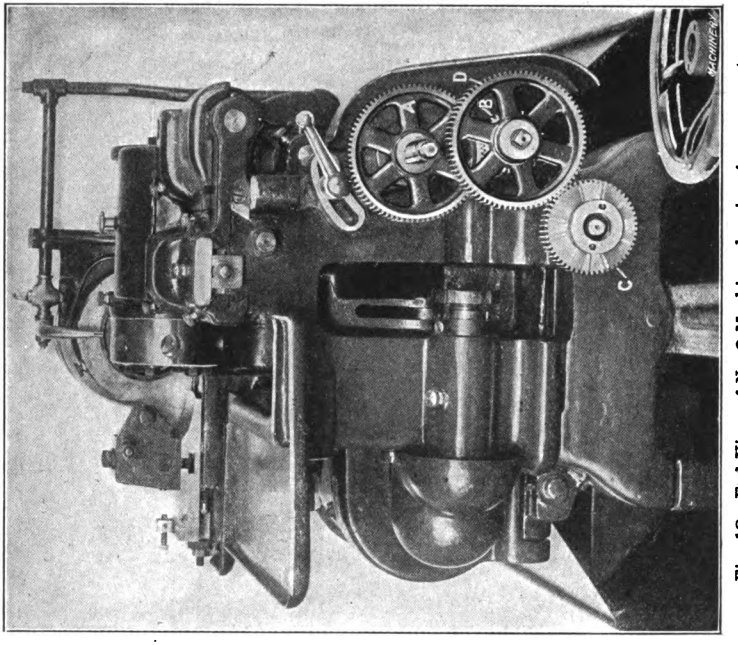


Fig. 18. End View of No. 2 Machine showing Arrangement of Change Gears

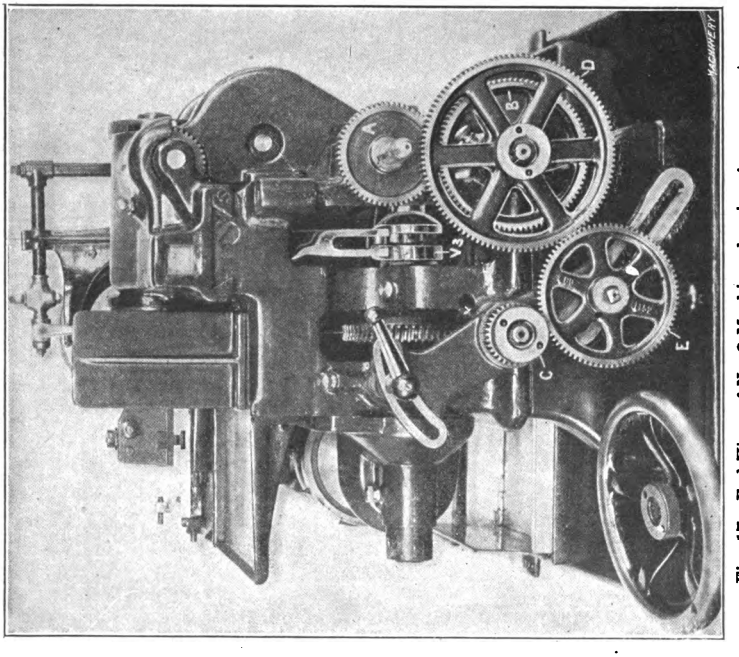


Fig. 17. End View of No. 0 Machine showing Arrangement of Change Gears

pin is withdrawn, the cam is forced out into engagement with the driving part of the clutch by a spring. The cam G_2 is located in the correct relation (each time it is disengaged from the driving clutch) to the collet closing mechanism by a V-groove in the cam body in which a stop K_5 in the lever L_5 fits. The stop is kept in contact with the cam body by a spring M_5 and is stopped in its "up position" by a stud N_5. All the tripping levers and clutches for the feeding, spindle reversing and turret indexing mechanisms are operated in a similar manner.

Operation of Oil Pump—Arrangement of Change Gears

The oil pump O_5, Fig. 2, is driven from the driving shaft by means of a chain and sprockets, which are shown guarded, and is provided

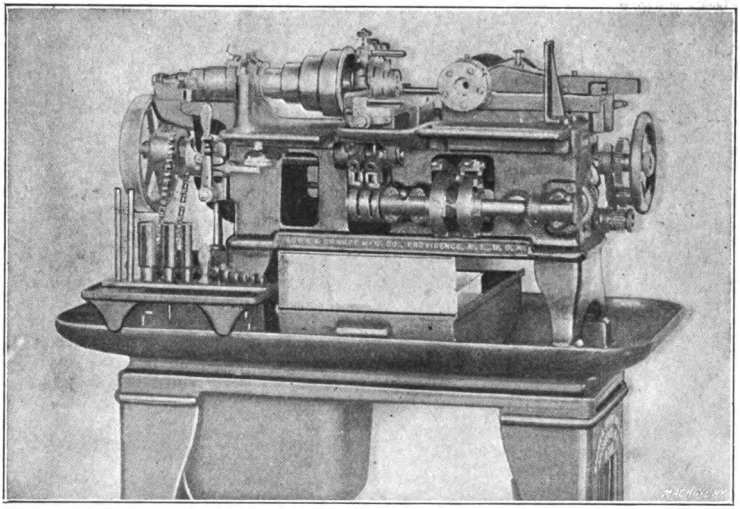


Fig. 19. No. 00 Brown & Sharpe Automatic Turret Forming Machine, Front View

with suitable piping. The pump is not stopped when the feed is disengaged, but continues in operation, thus insuring a steady stream of oil as soon as the tools commence to cut. Care should be taken to see that the pipe is not blocked up and that the oil pan is filled with oil. The oil is removed from the pan by opening the cock P_5, Fig. 1.

The speed of the front and lead camshafts is changed for the different jobs by means of change gears, as shown in Figs. 16, 17 and 18. Fig. 16 shows the arrangement of gearing for the No. 00 machine, where A is the gear on the driving shaft; B, the idler gear; and C the gear on the worm shaft. When it is desired to compound the gearing on this machine, another gear D is placed on the idler stud and a gear not shown is placed on the driving shaft. When the gearing is compounded, B becomes "first gear on stud," and D, "second gear on stud." The arrangement of the gearing for the No. 0 machine is shown in Fig. 17. Here A is the gear on the driving shaft; B, "first gear on stud"; D, "second gear on stud"; E, an intermediate gear; and C the gear on

the worm-shaft. On the No. 2 machine the gearing is arranged as shown in Fig. 18, where *A* is the gear on the driving shaft; *B*, "first gear on stud"; *D*, "second gear on stud"; and *C* the gear on the worm-shaft.

Automatic Turret Forming and Cutting-off Machines

The automatic turret forming machine, the No. 00 size of which is shown in Fig. 19, is intended for work not requiring the reversal of the spindle. It is practically of the same design and capacity as the regular automatic screw machine, except that it is driven by a four-step cone pulley. The preceding description applies to these machines in general, and the collets, cams, tools, etc., are all interchangeable with the regular "automatics" of the same size.

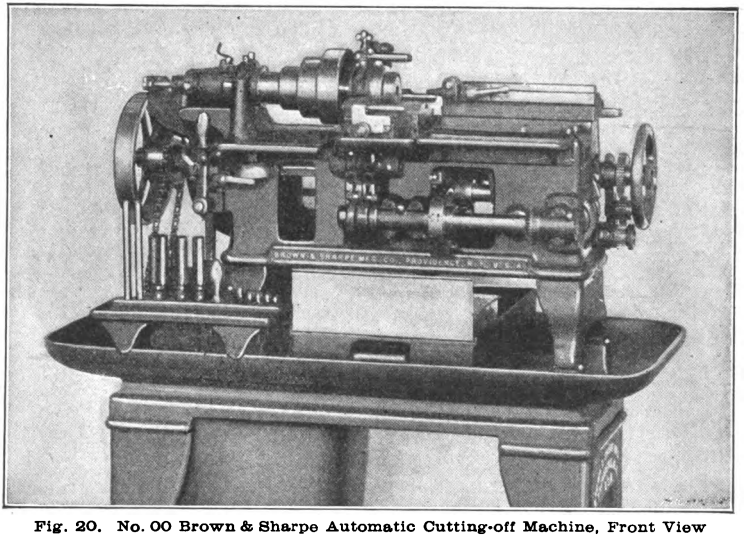


Fig. 20. No. 00 Brown & Sharpe Automatic Cutting-off Machine, Front View

The automatic cutting-off machine, size No. 00 of which is shown in Fig. 20, is driven by cone pulleys in the same manner as the turret forming machines and at the same speed. It has no turret, but is provided with a tool-slide for carrying a stop hollow-mill, box-tool or drill. It is of the same chuck capacity as the regular automatics, but the tool-holder is adjustable so that much longer work can be accommodated. The tool-slide on the No. 00 machine has a movement of 1¼ inch. The shortest distance (approximately) between the face of the tool-holder and the face of the collet when the lead lever roll is on the largest diameter of the cam, is 1¾ inch on the No. 00, 2 inches on the No. 0, and 2½ inches on the No. 2 machine. The greatest distance obtainable, approximately, with the lead lever roll on the smallest diameter of the cam, is 10 inches on the No. 00, 14 inches on the No. 0, and 17 inches on the No. 2 machine. The tools, cams, collet, etc., are interchangeable with the regular automatic screw machines of the same size.

CHAPTER II

SETTING THE TOOLS AND OPERATING AUTOMATIC SCREW MACHINES

In "setting-up" the Brown & Sharpe automatic screw machines, the most simple tools should, generally, be set first. As a rule these are the circular form and cut-off tools which are held on the cross-slides. Before any of the tools are set, however, the collet and feed finger should be changed for the size of work required, the proper change gears put on, and the driving belt placed on the required step.

Setting the Circular Form and Cut-off Tools

After the feed finger and spring collet have been put in place, the stock is inserted and pushed out far enough so that it can be faced off with the circular cut-off tool. The cut-off tool is then clamped to the toolpost and set with its cutting edge as close as possible to the height of the center of the work. The spindle is rotated and the end of the stock faced off, using lever K_2, Fig. 21, to operate the cross-slide. This procedure is followed until the cut-off tool is set correctly. The circular form tool is then clamped to the toolpost and the same procedure followed.

Fig. 21 shows an operator setting the cutting edge of a circular form tool to the height of the center of the work by means of the adjusting nut L_3. Care should be taken in setting the circular form and cut-off tools so that they will form the work parallel, and cut it off with a square face. This is accomplished by means of the adjusting screws a in the rear of the toolpost, which can be adjusted when nut K_3 is slackened slightly. When a circular form tool is placed on the front cross-slide, it is necessary to put the rising block N_3 under the toolpost. All dirt and oil should be removed from the surfaces of the rising block, toolpost and cross-slide, so that the cutting edge of the circular form tool, which should be ground at right angles to the side face, can be set parallel with the center line of the work. If this is not done, it will be found that the work will be slightly tapered.

The rolls in the cam levers require careful attention. If the pin in these rolls are not a good running fit, the roll will stick and wear out of round. This will result in the production of pieces which vary in diameter, due to the changes of position of the roll for the different pieces.

In setting the tool on the front cross-slide, the cutting edge should never be below the center of the work, but should be set preferably above or at the height of the center. The cutting edge of the tool on the rear cross-slide should be set just the reverse in reference to the center of the work, when the latter is running forward. When the work is running backward, the position of the cutting edges of the

tools on the front and rear cross-slide should be reversed from that for the forward rotation of the work. If the cutting edges of the circular tools are not set in the positions described, the work, when rotating, has a tendency to pull them around, thus increasing the diameter of the work, and causing chattering.

When the circular form tool is used for finishing the work to an exact diameter, the set-screw C_3, Fig. 21, should always be set so that it will come in contact with the stop D_3 when the work is turned to the desired diameter. In setting this stop it should be so adjusted that it will put a slight strain on the cross-slide operating lever. The

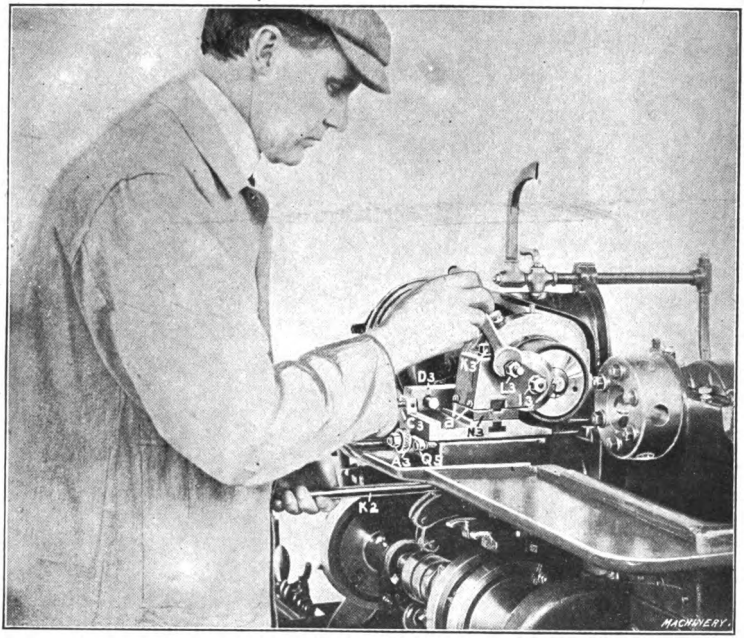


Fig. 21. Operator setting a Circular Form Tool

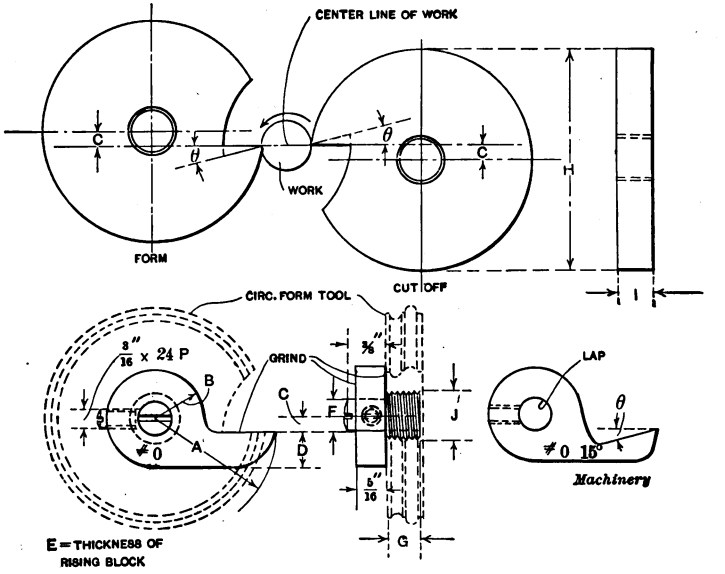
resulting action keeps the roll in close contact with the cam, and thus assures the parts formed being of the same diameter. When the circular form tool wears slightly, the set-screw C_3 can be adjusted back a slight amount, and the strain which has been set up in the lever will allow the tool to turn the work to the desired diameter. The cross-slide is adjusted back and forth to bring the cross-slide tools in contact with the work by means of split nut A_3, which is locked by means of a screw. Gib Q_3 should be adjusted so that there will be no unnecessary side play of the cross-slide in the bed.

Sharpening Circular Form and Cut-off Tools

The circular form and cut-off tools should be carefully sharpened when they become dull. If the cutting edge is not ground at right angles to the side face of the circular tool, the work produced will be

slightly tapered. For this reason the circular tool when being sharpened should be held on a table, the top surface of which is at right angles to the side face of the emery wheel. The cutting edge is then brought up against the side face of the emery wheel, and the tool ground. To insure that the tool is ground correctly, a templet similar to that shown in the illustration accompanying Table I is made for

TABLE I. PROPORTIONS FOR TEMPLETS AND CIRCULAR TOOLS



Number of Machine	Dimensions in Inches									
	A	B	C	D	E	F	G	H	I	J
00	1	7/16	1/8	5/16	1/4	1/4	7/32	1 1/4	1/4	3/8–16 P. R. H.
0	1 1/4	1/2	5/32	11/32	5/16	5/16	9/32	2 1/4	5/16	1/2–14 P. R. H.
2	1 5/8	5/8	1/4	3/8	3/8	3/8	11/32	3	3/8	5/8–12 P. R. H.

the circular tools used on each size of machine. The dimensions of this templet for the various sizes of machines are given in this table. The distance *G* is made less than the thinnest tool, so that the screw will not prevent the tool from lying flat on the table when grinding.

These templets should preferably be made of tool steel, hardened and ground as indicated. The hole should be lapped and the plug made a good fit for it. To the right of the illustration a templet is shown with its top face ground at an angle θ, and the size of the machine and angle stamped on it. Circular tools are ground with top rake for cut-

ting machine steel, tool steel, etc. The cutting angles for the various materials are as follows:

ANGLE OF TOP RAKE ON CIRCULAR TOOLS

Material	Angle θ, in Degrees
Brass rod	0
Drill rod and tool steel	8 to 10
Gun-screw iron	12
Machine steel	15
Norway iron	18

The sizes and pitches of the tapped holes in the circular tools are listed in column *J* of Table I, where the thread is given as right-hand. Sometimes the tools are tapped left-hand, especially in the case of wide

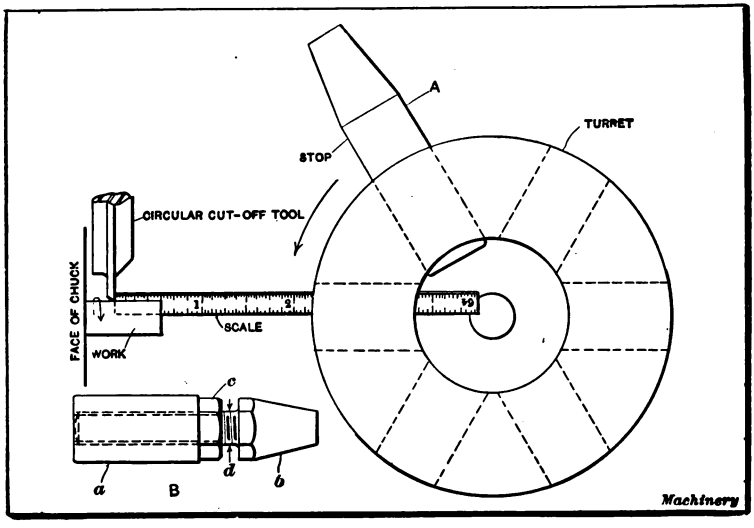


Fig. 22. Simple Method for setting a Stop

forming tools; they are then set on the front cross-slide, with the work running forward. As a rule, the tools are tapped right-hand and the hook bolt M_3 and bolt I_3, Fig. 9, tightly clamped, thus holding the circular tool securely.

Setting the Stop

When the circular cut-off tool has been set correctly, the chuck is opened by lifting the tripping lever, and the stock is fed out the desired length by hand; this length can be easily measured off by the method shown in Fig. 22. A flexible scale, the length of which depends on the size of the machine, is placed in an empty hole in the turret and brought up against the inside face of the circular cut-off tool. The cut-off tool is now brought up against the work by means of the handle operating the cross-slide. It is then an easy matter to set the stock to the desired length. When this has been done, the chuck is closed and the turret swung around so that the stop comes in line with the stock.

When the stop is in this position, the roll should be on the quick rise of the lead-cam so that by rotating the cam, the roll will rise up onto the lobe, thus forcing the stop back into the turret the required amount, where it can be locked with the lock-screw provided for that purpose.

When it is necessary to have the length of the piece to within a limit of 0.010 inch or less, the stop *A* in Fig. 22 gives considerable trouble, because the only way in which it can be set is by tapping it in or out, which is a rather difficult matter. A stop which gives better results is shown at *B*. The parts *a*, *b* and *c* are made from machine steel and casehardened. The body *a* is drilled and tapped for a screw the diameter of which is made in accordance with the size of the machine in which the stop is to be used: For the No. 00, $d = 5/16$ inch; for the No. 0, $d = 3/8$ inch; and for the No. 2, $d = 1/2$ inch.

For the No. 00 machine the number of threads per inch of the screw should be thirty-two, which would mean that one revolution would give

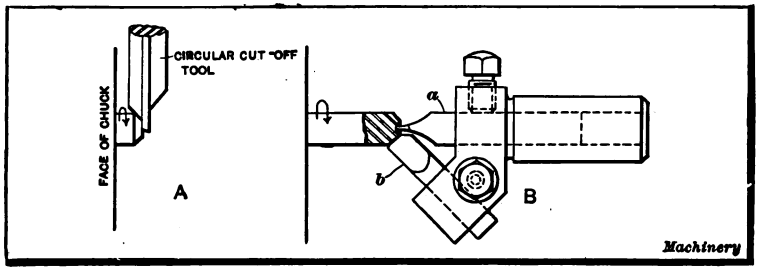


Fig. 23. Chamfering the End of the Work

an adjustment of 0.03125 inch. For the other machines, the screw should have twenty threads per inch. The stop proper, *b*, is made of hexagonal stock to fit the standard wrenches supplied with the machines. The nut *c* is made of the same shape and from the same size of stock as *b*. By having the stop hexagonal, as shown, it is an easy matter to set it within 0.005 inch, by means of the faces on stop *b*, as the relation of these to the nut can be noted, provided the latter is held with a wrench while part *b* is rotated.

Setting a Hollow-mill or Box-tool

Before reducing the diameter of the work by means of a hollow-mill or box-tool, it is necessary to chamfer the front end of the work to facilitate the starting of the cutter on a light cut until the tool is properly supported. One method of pointing the end of the work is shown at *A* in Fig. 23. Here the circular cut-off tool has an angular projection on its face next to the chuck, which points the bar before it is fed out for the next piece. This method is generally used when the work is not very long and runs practically true. It is sometimes impossible, however, to point the bar with a cut-off tool, and in that case the bar is usually pointed by a combination centering and pointing tool, as shown at *B*. This tool can be used when the bar does not project more than $3\frac{1}{2}$ times its diameter from the face of the chuck, and

when it is unfinished or of irregular shape. Tool *a* is used for centering the work, thus preparing it for drilling a hole, while tool *b* is used for pointing the end of the bar.

In setting a box-tool, the bar should project out of the spring collet only far enough to allow it to be turned down for a short distance; otherwise the work will not be held rigidly, and will spring away from the cutting tool. The cutting tool is first set to turn the work to within about 0.0005 or 0.001 inch of the finished diameter; then the supports are forced up tightly into contact with the work and clamped. It will be found that when the stock is fed out to the desired length, the supports bearing against the work tightly, the tool turns it slightly

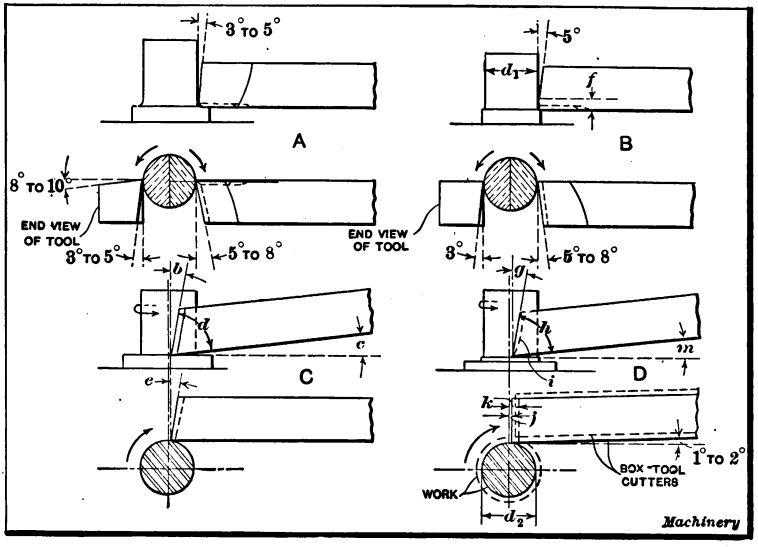


Fig. 24. Cutting-angles for Box Tool Cutters

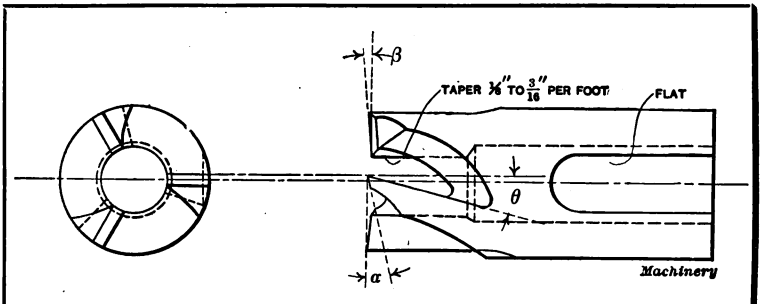
smaller in diameter. The box-tool cutter is brought in contact with the work by means of the handle K_2, Fig. 21, on the No. 00 machine, which is inserted in the lead lever O_4, Fig. 13, and by the lever R_5 on the Nos. 0 and 2 machines, as shown in Fig. 33. These levers should always be removed before engaging the driving clutch. For additional information regarding the application of external tools to the work, see MACHINERY'S Reference Book No. 102, "Automatic Screw Machine Practice—External Cutting Tools."

Cutting-angles for Box-tool Cutters

The cutting angle on a box-tool cutter depends largely on the method used in holding it, and on how it is applied to the work. In Fig. 24 a few methods of the application of box-tool cutters to the work are shown, and the angles at which they should be ground for various materials. A box-tool cutter, to give good results, should have sufficient clearance and rake so that it will remove the metal with the least

possible resistance. Generally, in automatic screw machine work, the box-tool cutter is set radially to the work, for cutting brass, as shown at *A*. When held in this manner the cutting angles are approximately as given in the illustration. This type of tool is used particularly for roughing work. For finishing work on brass, the tool is set as indicated at *B*, and the cutting face is ground parallel for a short distance *f*, which for usual conditions equals one-fifth of the smallest diameter of the work being turned. For steel, the box-tool cutter should be set tangentially to the work, as shown at *C* and *D*.

TABLE II. CUTTING ANGLES FOR HOLLOW-MILLS



Angle	Material to be Cut		
	Brass Rod	Machine Steel	Tool Steel
	Cutting Angle in Degrees		
α	8	15	10
β	8	5	3
θ	0	15	10

The angles on the box-tool cutter shown at *C* for cutting various materials is as follows:

Cutting-angles for Tool Steel
$b =$ 8 deg.
$c =$ 8 to 10 deg.
$d =$ 72 to 74 deg.
$e =$ 8 deg.

Cutting-angles for Machine Steel
$c =$ 8 to 10 deg.
$e =$ 10 deg.
$d =$ 70 to 72 deg.
$b =$ 10 deg.

The method of grinding the tools shown at *C* is commonly used for roughing purposes on steel, but will not produce an absolutely square shoulder on the work. For finishing cuts, the box-tool cutter is ground as shown at *D*.

The cutting angles for this type of tool are as follows:

Cutting-angles for Tool Steel
$m =$ 8 to 10 deg.
$g =$ 8 to 10 deg.
$h =$ 72 to 74 deg.

Cutting- angles for Machine Steel
$m =$ 10 to 12 deg.
$g =$ 15 to 18 deg.
$h =$ 60 to 65 deg.

While the cutting face on the tool shown at *D* is straight, it is usually advisable, especially when cutting machine steel and Norway iron to give it more "lip," and is indicated by the dotted line *i*. This produces a curling chip, and is conducive to better and more efficient cutting. It is not advisable in most cases to make the box-tool cutters for finishing from high-speed steel for cutting steel and Norway iron, if an exceptionally good finish is desired.

At *D* in Fig. 24 is shown the method used in adjusting the tangent cutter. The face of the cutter should be set at a distance *j* back from the center of the work. This gives the tool more clearance on the periphery of the work. The distance *j* should equal (for Norway iron and machine steel) one-tenth of the smallest diameter of the work being turned. When the tangent cutter is adjusted in a vertical direction, it should also be moved back an amount equal to *k*, as shown by the dotted lines in the illustration, so that *k* bears the same relation to the larger diameter as *j* does to the smaller.

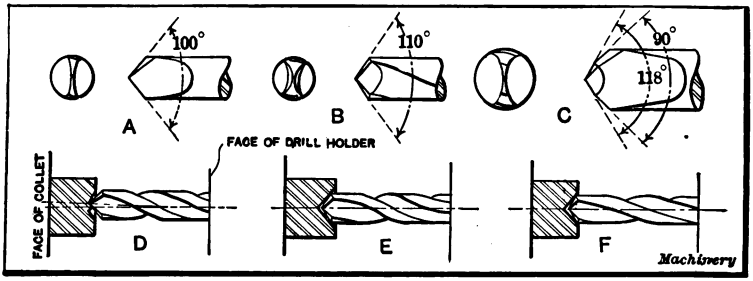


Fig. 25. Centering Tools—Incorrect and Correct Methods of Centering

Sometimes, when cutting machine steel, it is advisable to set the tool at an angle of from 1 to 2 degrees from the horizontal plane. This increases the clearance between the periphery of the work and the cutting face of the tool, and is accomplished by means of adjusting screws in the box-tool.

Cutting-angles for Hollow-mills

The illustration accompanying Table II shows a type of hollow-mill which is used on the automatic screw machine in cases where it is necessary to remove a large amount of material. The cutting angles for the lips of the hollow-mill are given in this table for various materials. Unless the operator has equipment sufficiently accurate to grind hollow-mills, he should not attempt to do so, as unsatisfactory results will be obtained if all the prongs or teeth do not do their share of the cutting. Preferably hollow-mills should be sharpened in the toolroom on an ordinary cutter grinder.

Setting Centering Tools and Drills

When the drill used is less than ⅛ inch in diameter, and is to pass entirely through the work, a centering or spotting drill should always be used. The centering tool should be ground and set so that it will not leave a teat in the work. It also should have an included angle less

than that used on the drill. In Fig. 25, three types of centering tools are shown at *A*, *B* and *C*. The tool shown at *A* is used principally for brass work, while that shown at *B* is used for steel work, and is made similar to an ordinary twist drill. The tool shown at *C* is used when a large center is to be "spotted" in steel.

At *D* is shown the effect of using a centering tool with an included angle greater than that used on the drill, and also by having it set so that it leaves a teat in the hole. It is evident that when the drill is projecting out of the holder for a considerable distance (because it is to pass entirely through the work) it will not enter concentrically, but

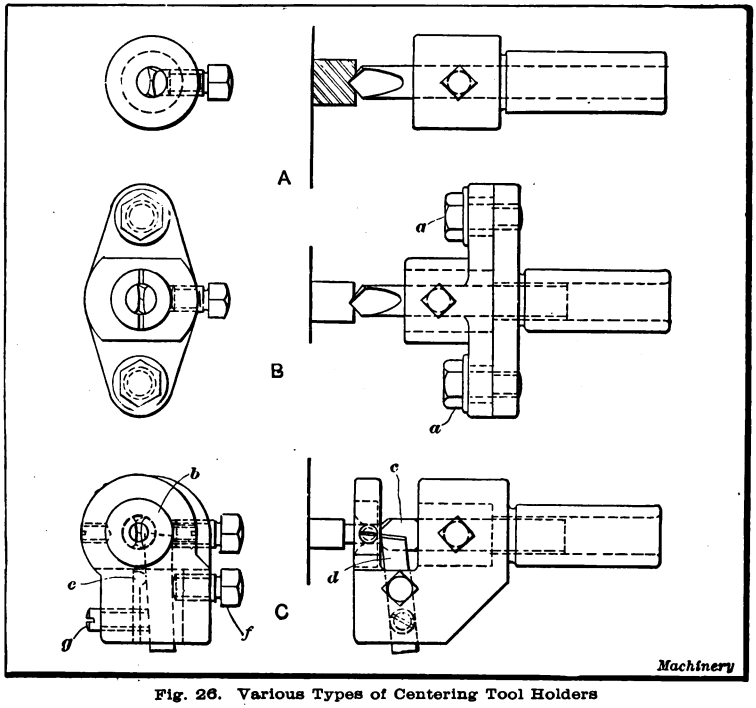


Fig. 26. Various Types of Centering Tool Holders

will be deflected by the teat. If the centering tool is made with an included angle less than that used on the drill, the result will be as shown at *F*, even if a teat has been left in the hole. Here the drill is well supported before its point would touch the teat; hence it would not be deflected. At *E* is shown the position that a drill should take in a correctly centered hole.

Holders for centering tools are illustrated at *A*, *B* and *C* in Fig. 26. The type of holder shown at *A* is frequently used, but is not recommended, owing to the difficulty of setting the centering tool concentric with the work. Preferably the floating holder shown at *B* should be used, as the centering tool can then be set concentric, after which the screws *a* are tightened. The holder shown at *C* is used when the work

projects to a considerable distance out of the collet, and the center is to be concentric with the part already turned. This holder carries a bushing *b*, held by a screw in the front part of the holder, a centering tool *c*, and facing tool *d*. The centering tool *c* is retained in a bushing by a set-screw, while the facing tool *d* is held down on block *e* by another set-screw. The headless screw *g* is used for adjusting.

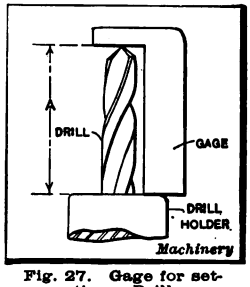


Fig. 27. Gage for setting a Drill

To set the centering tool *B*, the holder carrying it is placed in the turret, the latter swung down, the spindle stopped, and the centering tool brought in contact with the work. The screws *a* are then loosened, the tool set concentrically, and the screws tightened. The lead cam is then rotated by handwheel V_5, Fig. 29, until the roll rises up onto the starting point of the lobe for feeding the centering tool into the work. The holder is tapped back into the turret so that the point of the tool just clears the end of the work; then the holder is clamped in the turret. If upon trial it is found that the centering tool does not project in to the required distance, it is a simple matter to bring it out.

Before setting the drill, see that it is ground correctly for the material upon which it is to work, that is, to the desired angle and lip clearance. For brass work, the lip should be almost ground off, especially when a broken chip and not a curling one is desired. For steel the drill should be given a fairly good lip. The procedure given for

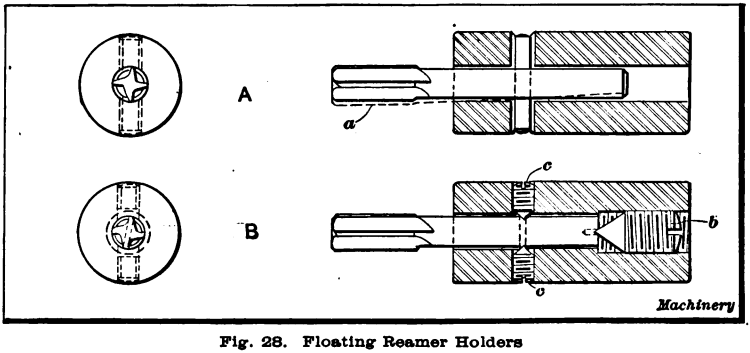


Fig. 28. Floating Reamer Holders

setting the centering tool also applies to setting a drill. For information regarding drill grinding see Chapter IV of MACHINERY'S Reference Book No. 94, "Operation of Machine Tools—Drilling Machines."

Prepare in time for the failure of a drill, as considerable time is lost in regrinding and resetting. A good idea is to have a number of drills lying on the tray already ground, and to use a gage for setting the drills as shown in Fig. 27. This gage is made from sheet steel about 1/16 inch thick. The dimension *A* is made equal to the distance that the drill is required to extend out of the holder. If there is more than

one drill in the turret, which would be necessary when a deep hole is to be produced, a gage of this description should be made for setting each drill. These gages should be marked according to the position that the drill for which they are used takes in relation to the other drills; that is, "1st," "2nd," etc., and kept in the same box as the other tools used on the job. If this precaution is taken, no time will be lost in setting a drill, because the machine need not be stopped. The clamping screw holding the drill can be released, the drill pulled out and a fresh one inserted while the machine is running.

Setting Counterbores and Reamers

A counterbore provided with a leader should always be held in a floating holder. Before setting the counterbore, of course, the hole should be drilled; then the procedure for setting centering tools

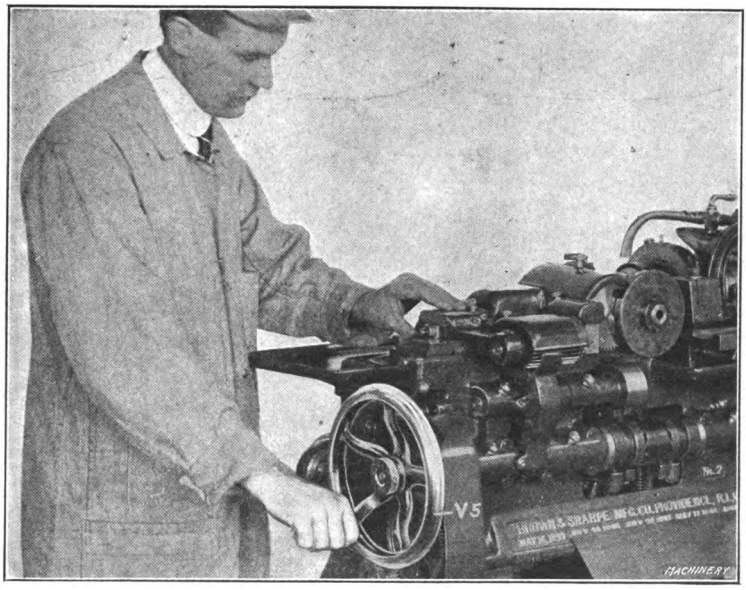


Fig. 29. Operator setting the Spindle Reversing Dogs for Threading

should be followed, except that the leader is inserted, bringing the face of the counterbore in contact with the end of the work. When the counterbore is not provided with a leader, a floating holder similar to that shown at *B* in Fig. 26 should be used.

Reamers which are to produce deep holes should be held in floating holders. Two types of floating holders are shown at *A* and *B* in Fig. 28. The one shown at *A*, however, is not recommended for automatic screw machine work, because the reamer drops down as shown at *a* if too much clearance is allowed between the hole in the holder and the reamer shank, thus preventing the reamer from centering easily into the work, and sometimes breaking it. The holder at *B* should be used in preference, because the reamer is guided by means of the screws *b*

and c, and can be given the desired amount of "float" by screws e. When a reamer is only to project a short distance into the work, the holder shown at B in Fig. 26, can be used.

Setting Dies and Taps

Before a die or tap and its holder are placed in the turret, the dogs should be set in position to reverse the spindle in the correct relation to the threading lobe on the lead cam. The two parts of clutch M (see Figs. 1 and 6) should first be engaged, so that the shaft carrying the disk on which the dogs are located will be rotated in step with the other driving mechanism of the machine. Then the shifter is pulled over and the main spindle started. The lead-cam is now rotated by means

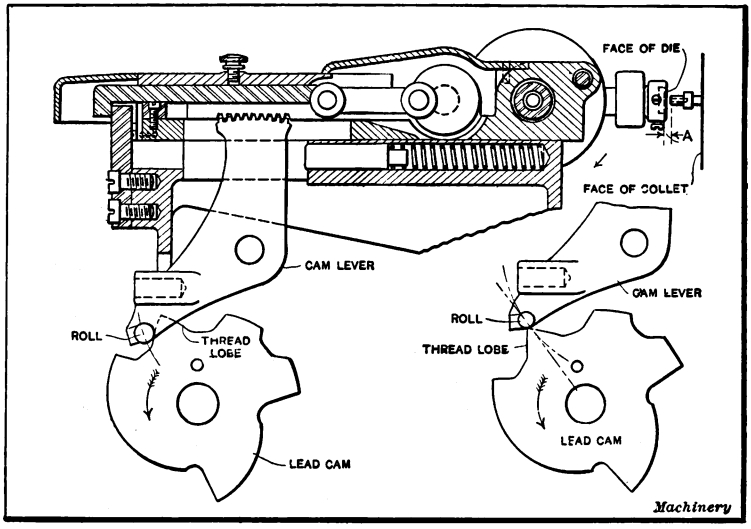


Fig. 30 Fig. 31

Showing the Position of the Roll on the Cam Lobe Relative to the Reversal of the Spindle

of hand-wheel V_5, Fig. 29, the operator also pressing his thumb against the turret slide and bearing on the turret base. While rotating the hand-wheel V_5, he watches to see when the spindle reverses; and by keeping his thumb in contact with the turret slide he can tell when the roll drops over the highest point of the lobe on the cam. When the spindle reverses at the same instant that the roll drops over the highest point of the lobe on the cam, the dog is set in the desired position. This is illustrated graphically, for setting a die, in Figs. 30 and 31. In Fig. 30 a button die is shown, held in a holder, in position ready to start on the work. The face of the die should be set the distance A from the end of the work. This distance varies from 1/16 to 3/16 inch, depending on the pitch of the thread and the length of the threaded portion. In Fig. 31 the cam roll is set just back of the highest point of the lobe; when the roll is at this point, the spindle should reverse.

After the first setting, if it is found that the die does not travel onto the work far enough, the holder is brought further out of the turret. The same procedure is followed in setting a tap, except that it should be set more carefully, only going into the work a slight distance when starting, and the holder moved out of the turret until the desired depth is reached. It is sometimes found necessary, after setting the tripping dogs, to adjust them slightly, especially when using the draw-out type of die or tap-holder. The turret should not be indexed until the die or tap is clear of the work.

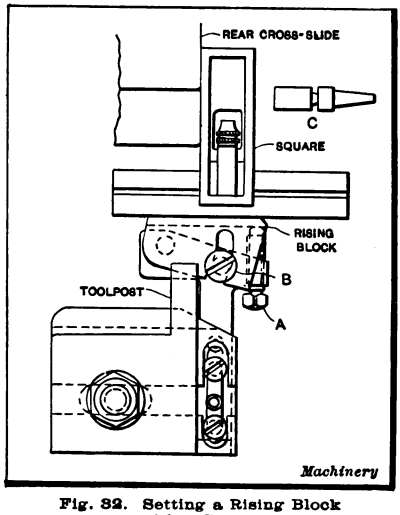


Fig. 32. Setting a Rising Block with a Square

Setting Swing Tools and Taper-turning Tools

Swing tools are used for both internal and external cutting, and are operated under three different conditions: first, the cutting tool is fed into the work from the cross-slide alone; second, the cutting tool is fed longitudinally by the turret; third, the cutting tool is fed inward by the cross-slide and longitudinally by the turret. For the first condition, the rising block need not be set in any particular relation to the axis of the spindle. When straight turning is to be produced under the second condition, the face of the rising block should be set parallel with the axis of the spindle. For the third condition, when the work is to be turned taper, the face of the rising block should be set at an angle with the axis of the spindle.

In Fig. 32 is shown a simple method of setting the face of the rising block parallel with the axis of the spindle. An ordinary adjustable square is held against the face of the rear cross-slide, and screw *A* is adjusted until the block is set correctly, after which screw *B* is tightened. This method can be used when it is not necessary to have the rising block set exactly parallel with the axis of the spindle.

A better and more accurate method is shown in Fig. 33. Here a Brown & Sharpe dial test indicator *B* is used. A split bushing is inserted in one of the holes in the turret, and a bent rod with the indicator is held in it. The finger of the indicator is brought to bear against the face of the rising block *C*, and the turret is traversed by handle R_5 on the No. 0 and 2 machines, and by using handle K_2, Fig. 21, on the No. 00 machine, inserting it in the turret traversing lever. While the turret is being traversed back and forth, the movement of the needle on the dial is noted, and the screw *A* adjusted until no movement is transmitted to the needle.

The setting of the rising block for operating a taper turning tool or a swing tool for taper turning is generally accomplished by the cut and try method, the first time the tools are set up. Most operators, when setting up a job for the second time, use what is called a "set piece" to set the tools by. This is a piece of work which has been made correctly to size, but which is not entirely cut off, as shown at *C* in Fig. 32. It is gripped in the collet, and the turning tool as well as the circular form and cut-off tools are set to it.

Setting Shaving Tools

There are two distinct types of shaving tools employed on the automatic screw machines, each type requiring the use of a different holder. Fig. 34 shows a shaving tool holder and shaving tool which

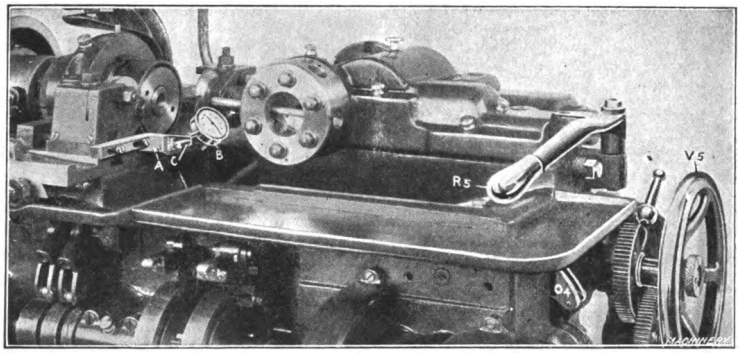


Fig. 33. Setting the Rising Block with the Aid of a Brown & Sharpe Dial Test Indicator

is used without a support for the work. This type of tool is used when the work is large enough in diameter to withstand the cutting pressure. The angles on the shaving tools shown to the right of the illustration for the different materials are as follows:

Material	Cutting-angle in Degrees
Brass rod	$A = 20$, $B = 30$, $C = 10$.
Machine steel	$A = 30$, $B = 40$, $C = 15$.
Tool steel	$A = 40$, $B = 50$, $C = 15$.

These angles need only be approximated, but the table gives a fair idea of preferable angles to which a shaving tool should be ground for shaving long work. Another type of shaving tool-holder and shaving tool is shown in Fig. 35. This type is used principally on steel work which is long in proportion to the diameter. It consists of a shaving tool *A* and support *B*. The support *B* is made an exact duplicate of the shaving tool *A*, except that it is not backed off for cutting, and is slightly rounded on the front end. It should always be set a slight amount back of the cutting edge of the shaving tool. At *C* and *D* is shown the way in which these shaving tools should be made. At *C* the tool is shown machined and ready for hardening, and at *D* the front part, shown partially separated at *C*, is removed and the tool ground ready for work. The cutting angles for this tool are as follows:

Material	Cutting-angle in Degrees
Brass rod	$a = 10$, $b = 10$.
Machine steel	$a = 15$, $b = 15$.
Tool steel	$a = 20$, $b = 15$.

Setting the Belt-shifting Attachment

The belt shifting attachment on the Nos. 0 and 2 machines, which is used for changing the spindle from a fast to a slow speed or *vice*

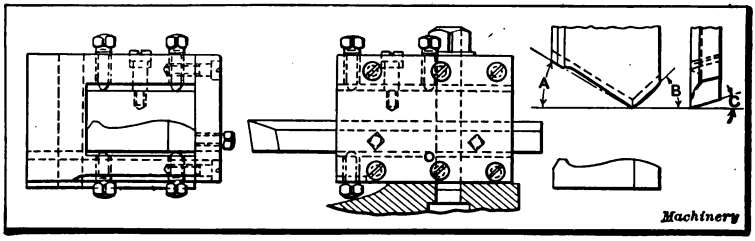


Fig. 34. Shaving Tool and Holder for Long Work

versa, is shown set up on a No. 0 machine in Fig. 36. This attachment is driven from the rear driving shaft through gears *A* and *B*, which rotate disk *C*, carrying rod *D*, the latter being connected eccentrically to the disk and operating the shifter on the countershafting, as illustrated in Figs. 42 and 43 and Figs. 44 and 45. Gear *A* has half as many teeth as gear *B*, so that for every revolution of the driving shaft the belt is shifted once. This attachment is operated by clutch *E*, which is brought into and out of engagement by a tripping lever

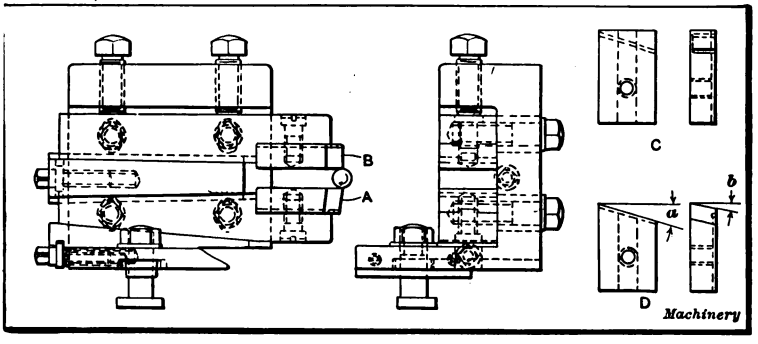


Fig. 35. Shaving Tool and Holder provided with a Support for the Work

and dog carried on the drum on the front camshaft. It is not advisable to shift the belt when a tap is in or a die on the work, but the spindle should rather be rotated at the lowest speed when the tap or die engages or disengages the work.

The No. 00 machine is not equipped with this belt shifting device, but for steel work a threading attachment as shown at *A* in Fig. 37 is used. This attachment is also supplied for the Nos. 0 and 2 machines, but its driving capacity is limited to the following sizes of taps or dies. For the No. 00, the maximum diameter of tap or die

that can be driven by this device is 1/8, 40 threads; on the No. 0 machine 3/16, 32 threads; and on the No. 2 machine 1/4, 22 threads. When a larger diameter tap or die and a coarser thread than this is to be cut in the No. 00 machine, the two speeds of the spindle are employed, which, of course, necessitates the using of left-hand turning

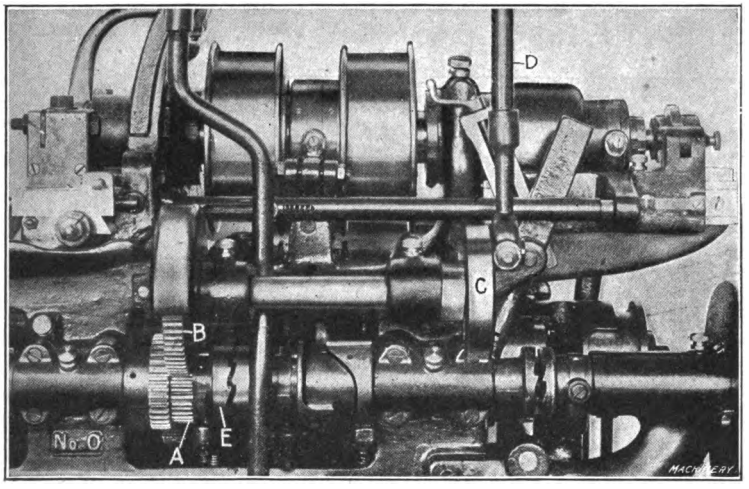


Fig. 36. The Belt-shifting Attachment used for Threading

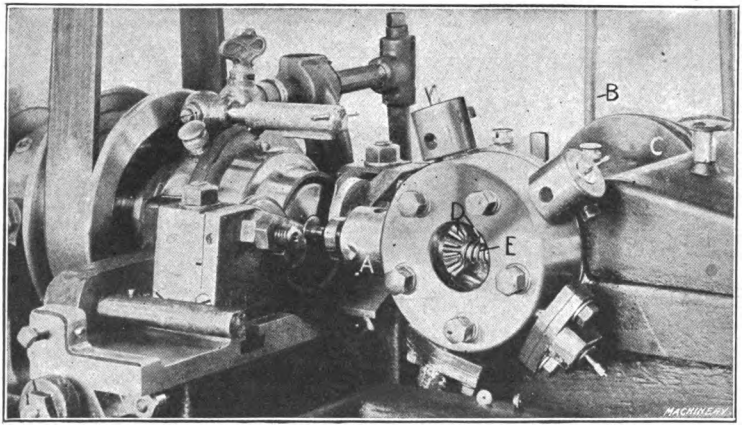


Fig. 37. Ratio Threading Attachment

tools in the turret. On the Nos. 0 and 2 machines, the belt shifting arrangement, previously described, should be used.

The ratio threading attachment shown at *A* in Fig. 37 is held in the turret and driven by a belt *B* from the countershaft, through pulley *C* and bevel gears *D*. The spring *E* acts in the same manner as the spring in the ordinary draw-out die or tap holder.

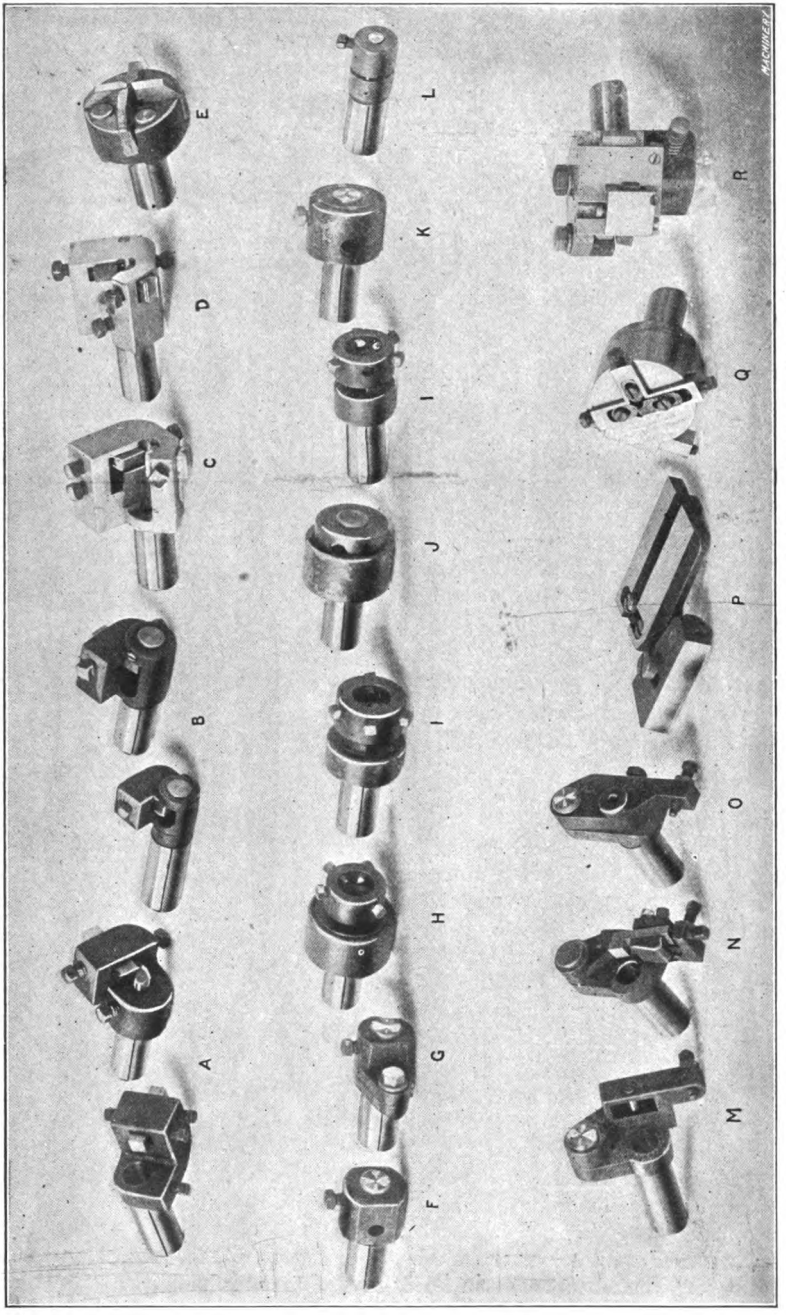


Fig. 38. Representative Group of Standard Tools for Brown & Sharpe Automatic Screw Machines

There are a number of special cross-slide and turret attachments which can be obtained for the Brown & Sharpe automatic screw machines for various operations. The method of setting these attachments, of course, is entirely governed by the work and the construction of the attachment itself. Figs. 38 and 39 show groups of standard tools which are used on the Brown & Sharpe automatic screw machines. The names of the tools shown in Fig. 38 are:

Knee tool, and centering and facing tools.	*A*,
Box-pointing tools.	*B*,
Box-tool (two cutters).	*C*,
Box-tool (one cutter).	*D*,
Adjustable hollow mill (finishing).	*E*,
Drill holder.	*F*,
Floating holder.	*G*,
Button die holder (releasing).	*H*,
Button die holder (draw-out).	*I*,
Tap holder (releasing).	*J*,
Tap holder (draw-out).	*K*,
Small tap holder (draw-out).	*L*,
Swing knurl or thread roll-holder.	*M*,
Swing turning tool.	*N*,
Recessing tool holder.	*O*,
Rising block with adjustable guide.	*P*,
Taper turning tool.	*Q*,
Angular cutting-off tool.	*R*,

The names of the standard tools shown in Fig. 39 are:

Turret knurl holder.	A_1,
Cross-slide knurl holder (side).	B_1,
Cross-slide knurl holder (top).	C_1,
Spring collet.	D_1,
Feed finger.	E_1,
Centering tool and turret back rests.	F_1,
Auxiliary work support.	G_1,
Double-throw cross-slide attachment.	H_1,
Slabbing attachment.	I_1,
Cross-slide cutting-off tool post (high).	J_1,
Cross-slide cutting-off tool post (low).	K_1,
Tool post for straight forming tools.	L_1,
Cross-slide drilling attachment.	M_1,
Brake for spindle.	N_1,

With the exception of the auxiliary work support shown at G_1 in Fig. 39, all of the standard tools and attachments illustrated are dealt within detail in MACHINERY'S Reference Books, Nos. 99 to 106, inclusive, on "Automatic Screw Machine Practice." The attachment G_1 is used for steadying the work and making it run "dead" true when it is desired to turn down a portion of the work perfectly concentric with the remainder of the piece, which is not to be operated on. This device is fastened over the hood enveloping the spring collet and ex-

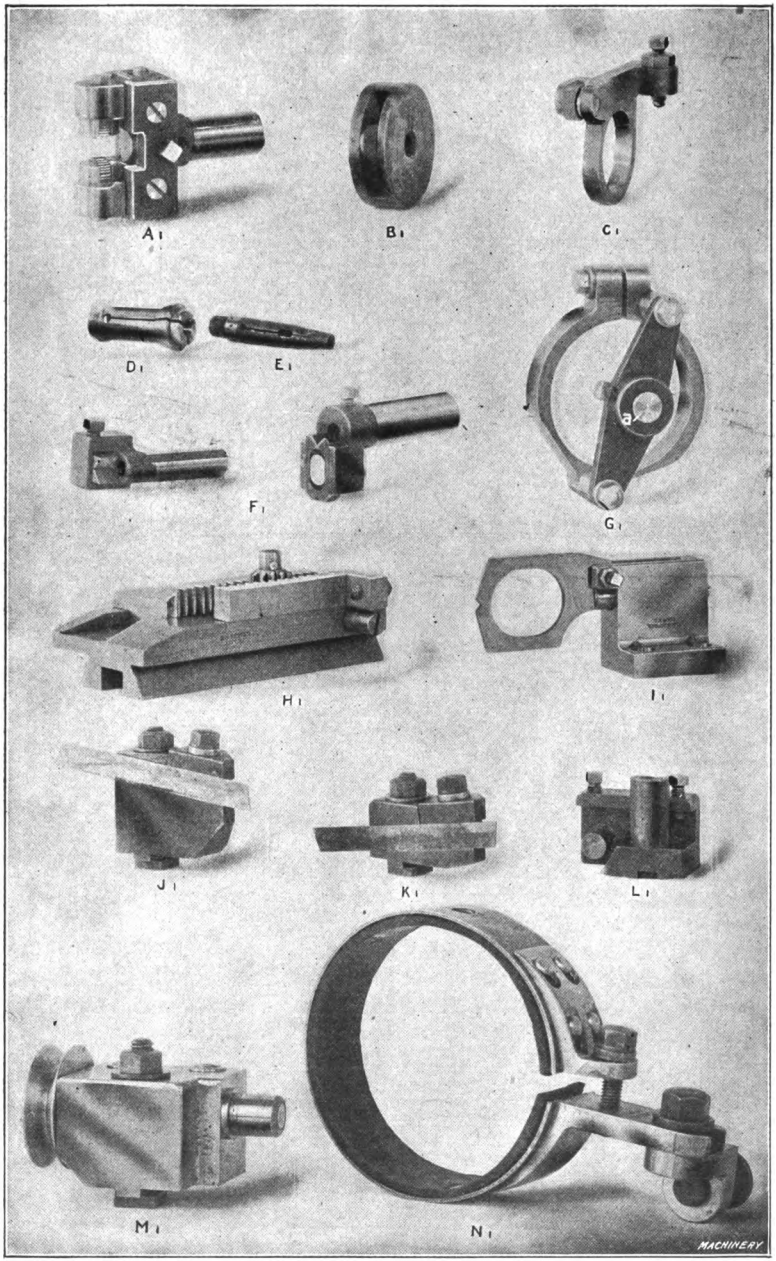


Fig. 39. Representative Group of Standard Tools and Attachments for the Brown & Sharpe Automatic Screw Machines

tends in front of the latter. The bushing *a*, shown solid, is then drilled and reamed out from the turret, after which it is hardened, inserted again and lapped.

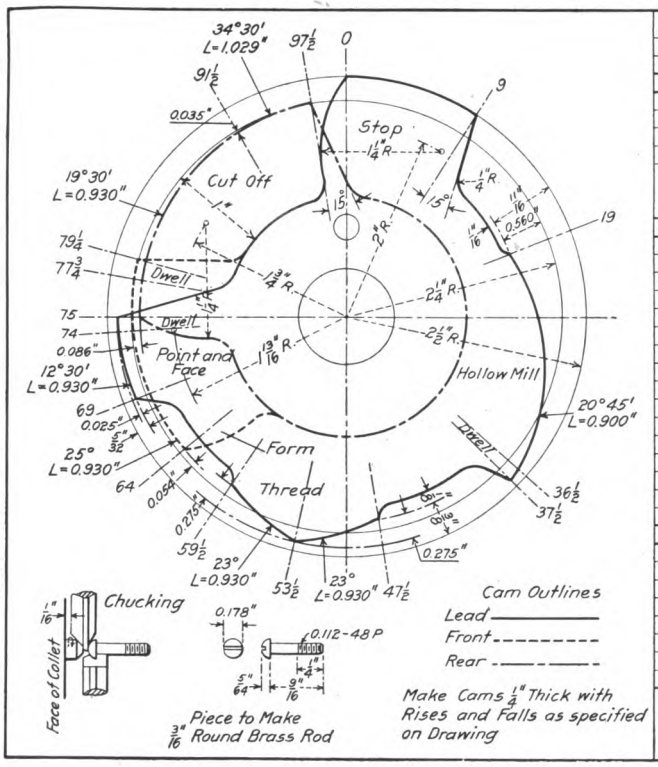
Instructions for Setting-up a Job on the Automatic Screw Machine

To illustrate the method followed in setting-up a job on the Brown & Sharp automatic screw machines, we will assume that a set of cams as illustrated in Fig. 40 have been designed and made for producing a button-head screw on the No. 00 machine. These came, together with the special and standard tools which are numbered, are turned over to the operator. He also receives a drawing similar to that shown in Fig. 40. We will assume that the machine has been set up for another piece of work, so that it is necessary to dismantle it. The first thing the operator does is to remove all the tools from the turret and the cams from the front and rear end shafts. He also removes the spring collet by removing the cap, and the feed tube by lifting the latch; then he unscrews the feed finger, which is threaded left-hand. The change gears are now removed, leaving the machine dismantled ready for the new job.

To proceed, the operator first inserts the spring collet, puts on the cap, and then screws the new feeding finger into the feed tube, and inserts the latter into the spindle. He then puts the stock into the feed tube, and places a suitable pipe in the stand in which the stock is to revolve. This pipe should be central with the feed tubes, thus reducing the wear in the hole of the latter. The belts are now placed on their proper cones, as illustrated in Fig. 41, to give the desired spindle speeds for the job. All belts should be without rivets, and preferably should be laced with wire, as this gives a smoother running belt. Now oil all the bearings with good machinery oil, and also the friction clutch. The latter should be oiled at least twice a day. Then see that the reservoir in the tank is filled with good lard oil, the latter being absolutely necessary if the machine is to be run economically and to its full capacity.

After the belts have been placed on the proper cones, the collet, feed finger, etc., having been inserted, the change gears should be put on as illustrated in Fig. 16. These gears are held by thumb nuts which should be tightened with the pin wrench supplied for that purpose. The handwheel V_5 is next put on for operating the machine by hand.

Before putting on the cams, set the collet so that it has the proper grip on the stock. The method for doing this has been described in Chapter I. Now open the collet again and push the stock out far enough to be faced off by the cut-off tool. Close the collet by means of the handle and start the spindle. Now set the cross-slide circular form and cut-off tools directly at the height of the center of the work, and in their proper relation to each other. Next put on the front and rear cross-slide cams; and if the job, as this one does, requires a threading operation, the shaft with the drum carrying the tripping dogs for reversing the spindle, should be connected with the front camshaft.



Name of Piece: Button Head Screw

Gears	Time to Make 1 Piece 6½ Seconds	Spindle Speeds	
No. 52 On Drive Shaft	Gross Production 10 hours = 5538	Forward	Backward
No. 34 On Worm Shaft	Made on No. 00 B. & S. Auto. Scr. Mach.	2400 R.P.M.	2400 R.P.M.
No. On 1st Stud	Material Used: 3/16" Round Brass Rod	R.P.M.	R.P.M.
No. On 2nd Stud	Remarks: Use 6 hole Turret	Surface Speeds	
	Machine, and Tool Numbers	For Stock	117.81 F.P.M.
	as specified	For Thread	70.37 F.P.M.
		For Drilling	F.P.M.

Rev's.	Hund's.	Start	Finish	Rise	Feed	Operations
23.4	9	0	9			Feed stock to stop and chuck
26.0	10	9	19			Revolve Turret
48.1	18½	19	37½	0.560"	0.0123"	Turn (Hollow Mill) Dwell 0.10
26.0	10	37½	47½			Revolve Turret
15.6	6	47½	53½	0.275"	0.122"-48	Die on } Reverse Spindle
15.6	6	53½	59½	0.275"	0.122"-48	Die off }
11.7	4½	59½	64			Clearance and Revolve Turret
38.65	15¼	64	79¼	0.054"	0.00155"	Form (Circular Tool) Dwell 0.15
15.6	6	69	75	0.025"	0.00192"	Point and Face Dwell 0.10
42.9	16½	75	91½	0.051"	0.00119"	Start Cut-off }
15.6	6	91½	97½	0.035"	0.00224"	Finish Cut-off } Circular Tool
6.5	2½	97½	100			Clearance

Special Tools	Tool No.	Dwg. No.	Standard Tools	Tool No.	Dwg. No.
Circular Form Tool	1678	L.7218	Stop	1368	T.S. 50
Circular Cut-off Tool	1679	L.7218	Floating Holder	1472	L.7685
Cams, Lead, Front, Rear	1680	L.7219	Hollow Mill	1763	T.S.100
Slotting Bushing	1681	L.6301	Button Die Holder	1875	L.7860
			0.112-48 P Button Die	1673	T.S.150
			Pointing and Facing Tool	1520	L.7679

Remarks:

Fig. 40. Setting-up Chart for making a Button Head Screw on the No. 00 Brown & Sharpe Automatic Screw Machine

Next, set in the cross-slides by adjusting nuts A_3, Fig. 21, so that the circular form and cut-off tools travel in to the required distance. Place the hollow-mill in the turret, set it correctly, and also set the tripping dog so as to revolve the turret. Put the box-tool in the turret, set it, and also set the dog for indexing the turret. The die is then set as previouslyy described, and all the tripping dogs are set to index the turret completely around. After all the tools have been set in their proper relation, make a piece, except threading, by turning the handwheel; at the threading operations drop down the die so that it does not pass onto the work. Gage the piece thus made; if it is correctly to size, and the tripping dogs for reversing the spindle and the die have been properly set, throw the feed clutch by means of handle *P*, Fig. 1, and start the machine.

When the bar is all used up, the chuck should be opened by tripping the lever, and the turret revolved by withdrawing the locking pin, so that it will not interfere with the short piece left in the chuck, which should be driven out for the insertion of a new bar. To insert the new bar, turn the handwheel sufficiently to bring the shoulder of the feed tube against the end of the spindle, and push out the bar just far enough so that its front end can be faced off with the cut-off tool. Now turn the turret back into position and start the machine by throwing in the clutch. The ends of the rods of stock should be ground to remove the burrs, thus insuring their entering and feeding freely and evenly through the feed tube.

The work should always be tested after the insertion of a new bar of stock. If the parts made are short or thin, the tools will become dull much more quickly; consequently the work should be tested more frequently in that case, so that any errors may be corrected as soon as possible.

CHAPTER III

COUNTERSHAFT ARRANGEMENT AND SPINDLE SPEEDS

The arrangement of the spindle speeds for the No. 00 automatic screw machine, as well as the spindle speeds of the No. 00 automatic turret forming and the No. 00 automatic cutting-off machines, are shown in Fig. 41. The spindle speeds obtainable on the No. 0 automatic screw machine, as well as the arrangement of the countershaft with respect to the main shaft, is shown in Figs. 42 and 43. The spindle speeds obtainable on the No. 0 automatic turret forming machine and on the No. 0 automatic cutting-off machine are also given. The arrangement of the spindle speeds for the No. 2 automatic screw machines are shown in Figs. 44 and 45, where the spindls speeds for the No. 2 automatic turret forming and automatic cutting-off machines are also given.

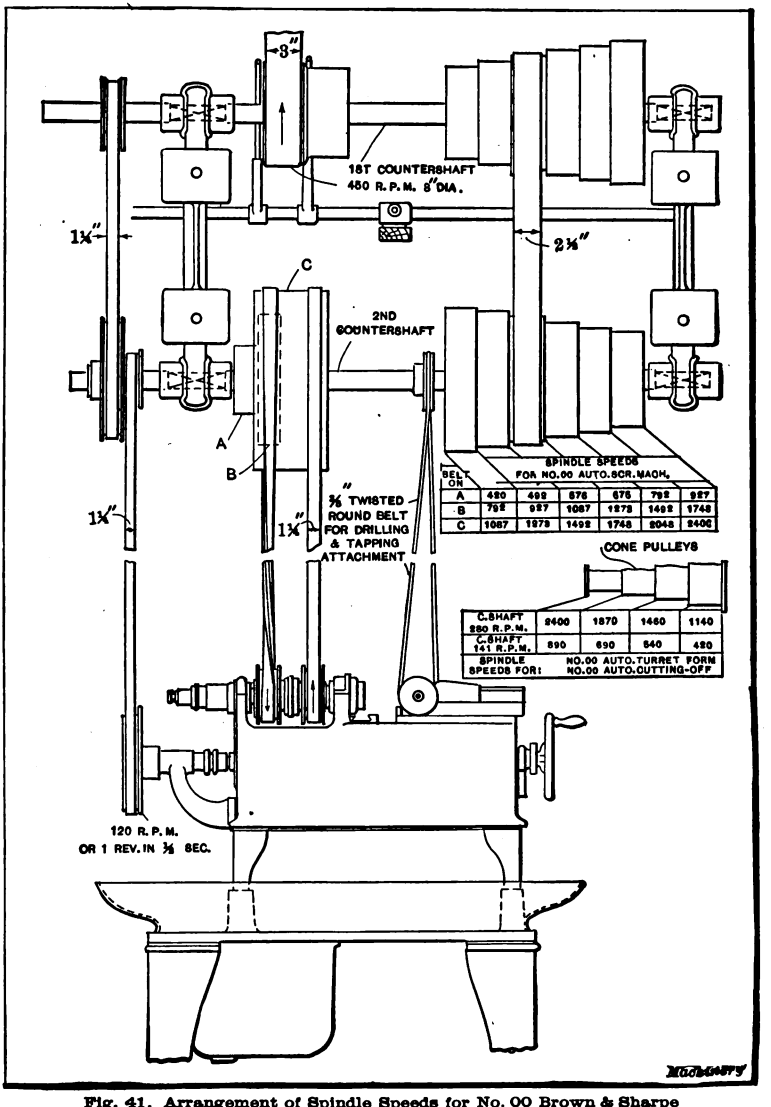
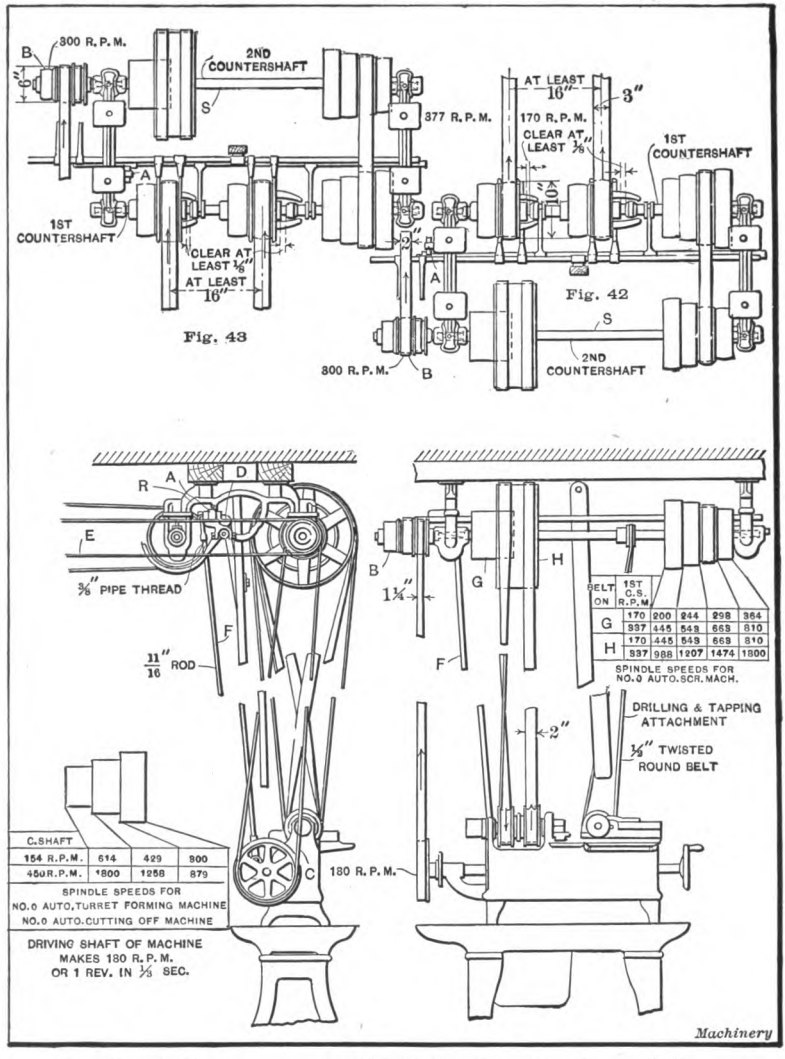


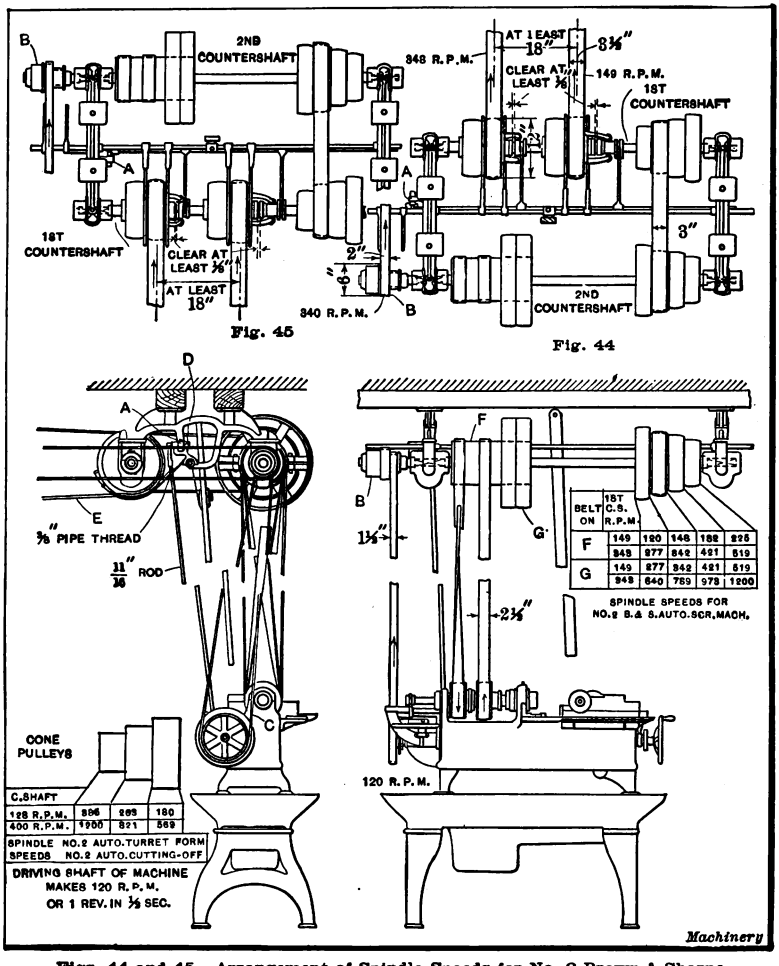
Fig. 41. Arrangement of Spindle Speeds for No. 00 Brown & Sharpe Automatic Screw Machines

The counter-shaft arrangement shown in Figs. 41 to 45 drives both the main spindle and the rear driving shaft. The rear driving shaft is driven independently of the cone pulleys by a double loose pulley mounted on the end of the second countershaft. This pulley acts as an intermediate between the main line and the feed mechanism, driving the latter at a constant speed. The belts are all controlled by means of one shifter handle.



Figs. 42 and 43. Arrangement of Spindle Speeds for No. 0 Brown & Sharpe Automatic Screw Machines

For the No. 0 machine, the countershafting may be set up as in Fig. 42 or as in Fig. 43, to suit the location of the main line-shaft. In Fig. 42, *A* is on the outside of the hanger, and in Fig. 43, on the inside. The first countershaft is always nearest the main line-shaft, and the sides *R* of the hangers are always its support. The long shaft *S* with pulley *B* may be placed in either pair of boxes, so that belt *C* will clear the feed-slide of the machine. If belt *E* interferes with the shifter-rod at *D*, belts *E* and *C* may be crossed. The belts will gen-



Figs. 44 and 45. Arrangement of Spindle Speeds for No. 2 Brown & Sharpe Automatic Screw Machines

erally clear, as the main line-shaft is usually lower than the countershaft. Rod *F* can be nearly vertical when the drilling attachment is not used.

For the No. 2 machine, the countershaft can be set up as in Fig. 44, or as in Fig. 45, to suit the location of the main line-shaft. In Fig. 44, *A* is on the outside of the hanger, and in Fig. 45, on the inside. The long shaft with pulley *B* can be placed in either pair of boxes, so that belt *C* will clear the feed-slide of the machine. If belt *E* should interfere with the shifter-rod at *D*, belts *E* and *C* may be crossed. Belt *E* will generally clear as the main line-shaft is, as a rule, lower than the countershaft.

TABLE II. SURFACE SPEED OF STOCK

Diameter of Stock	Decimal Equivalent	Revolutions Per Minute															
		2400	2048	1800	1748	1492	1474	1273	1200	1087	988	973	927	810	792	675	640
		Surface Speed in Feet per Minute															
1/16	0.062	39.3	33.5	29.4	28.6	24.4	24.1	20.8	19.6	17.9	16.2	15.9	15.2	13.2	12.9	11.0	10.5
5/64	0.078	49.1	41.9	36.8	35.7	30.5	30.1	26.0	24.5	22.2	20.2	19.9	18.9	16.9	16.2	13.8	13.1
3/32	0.094	61.4	52.4	46.1	44.7	38.1	37.7	32.6	30.7	27.8	24.2	24.9	22.7	20.7	20.3	16.6	16.4
7/64	0.109	68.5	58.4	51.3	49.9	42.6	42.0	36.3	34.2	31.0	28.3	27.8	26.5	23.1	22.6	19.3	18.3
1/8	0.125	78.5	67.0	58.9	57.2	48.8	48.2	41.6	39.3	35.6	32.3	31.8	30.3	26.5	25.9	22.1	20.9
9/64	0.141	88.6	75.6	66.4	64.5	55.1	54.4	47.0	44.3	40.1	36.4	35.9	34.1	29.9	29.2	24.9	23.6
5/32	0.156	98.0	83.6	73.5	71.4	60.9	60.2	52.0	49.0	44.4	40.4	39.7	37.9	33.1	32.4	27.6	26.1
11/64	0.172	107.9	92.1	81.0	78.6	67.1	66.3	57.3	54.0	48.9	44.4	43.8	41.7	36.4	35.6	30.4	28.8
3/16	0.187	117.8	100.5	88.3	85.8	73.2	72.3	62.5	58.9	53.3	48.5	47.8	45.5	39.8	38.9	33.1	31.4
13/64	0.203	127.6	108.9	95.7	93.0	79.3	78.4	67.7	63.8	57.8	52.5	51.7	49.3	43.1	42.1	35.9	34.0
7/32	0.219	137.6	117.3	103.1	100.1	85.4	84.4	72.9	68.7	62.2	56.6	55.7	53.1	46.4	45.3	38.6	36.6
15/64	0.234	147.3	125.7	110.4	107.2	91.5	90.4	78.1	73.6	66.7	60.6	59.7	56.9	49.7	48.6	41.4	39.3
1/4	0.250	157.1	134.0	117.8	114.4	97.6	96.5	83.3	78.5	71.1	64.7	63.7	60.7	53.0	51.8	44.2	41.9
9/32	0.281	176.7	150.8	132.5	128.7	109.8	108.5	93.7	88.3	80.0	72.7	71.6	68.2	59.7	58.2	49.7	47.1
5/16	0.312	196.3	167.5	147.3	143.0	122.0	120.6	104.1	98.2	88.9	80.8	79.6	75.8	66.3	64.7	55.2	52.4
11/32	0.344	215.9	184.3	161.9	157.3	134.2	132.6	114.6	107.9	97.8	88.9	87.6	83.4	73.0	71.2	60.7	57.6
3/8	0.375	235.6	201.0	176.7	171.6	146.4	144.7	125.0	117.8	106.7	97.0	95.5	91.0	79.6	77.6	66.3	62.9
13/32	0.406	255.2	217.8	191.4	185.9	158.5	156.8	135.4	127.6	115.6	105.1	103.5	98.6	86.3	84.1	71.8	68.1
7/16	0.437	274.9	234.5	206.2	200.2	170.7	168.8	145.8	137.4	124.5	113.2	111.4	106.2	92.9	90.6	77.3	73.3
15/32	0.469	294.5	251.3	220.9	214.5	183.0	180.9	156.2	147.3	133.4	121.2	119 4	113.8	99.6	97.0	82.8	78.5
1/2	0.500	314.2	268.1	235.6	228.8	195.1	192.9	166.6	157.1	142.3	129.3	127.4	121.3	106.2	103.5	88.3	83.8
17/32	0.531	333.8	284.8	250.3	243.1	207.3	205.0	177.0	166.9	151.2	137.4	135 3	128.9	112.9	109.9	93.9	89.0
9/16	0.562	353.4	301.6	265.1	257.4	219.5	217.1	187.5	176.7	160.1	145.5	143.3	136.5	119.5	116.4	99.4	94.2
19/32	0.594	373.1	318.3	279.8	271.7	231.7	229.1	197.9	186.5	168.9	153.6	151.2	144.1	126.2	122.9	104.9	99.5

TABLE III. SURFACE SPEED OF STOCK

Diameter of Stock	Decimal Equivalent	Revolutions per Minute															
		576	543	519	492	445	420	364	342	298	277	244	225	200	182	148	120
		Surface Feet in Inches per Minute															
9/32	0.281	42 6	40 0	38.2	36.2	32.7	31.7	26.8	25.2	21.9	20.4	18.0	16.9	14.7	13.4	10 8	8.8
5/16	0.312	47.1	44.4	42.4	40.2	36.4	34.4	29.8	28.0	24.9	22.7	20.1	18.4	16.4	14.5	12.1	9.8
11/32	0.344	51.8	48.9	46.7	44.3	40.0	37.8	32.7	30.8	26.8	24.9	21.9	20.2	18.0	16.4	13.3	10.8
3/8	0.375	56.5	53.3	50.9	48.3	43.8	41.2	35.7	33.6	29.3	27.2	23.9	22.1	19.6	17.9	14.5	11.8
13/32	0.406	61.2	57.7	55.2	52.3	47.3	44.7	38 7	36 4	31.7	29.5	25.9	23.9	21.3	19.4	15.7	12.8
7/16	0.437	66.0	62.2	59.4	56.4	51.0	48.1	42.6	39.2	34.1	31.7	27.9	25.8	23.0	20.8	16.9	13.7
15/32	0.469	70.7	66.6	63.7	60.4	54.6	51.5	44.6	42.0	36.6	34.0	29.9	27.6	24.5	22.3	18.6	14.7
1/2	0.500	75.4	71.1	67.9	64.4	58.2	55.0	47.6	44.8	39.0	36.3	31.9	29.5	26.2	23.8	19.4	15.7
17/32	0.531	80.1	75.5	72.2	68.4	61.9	58.4	50.6	47.6	41.4	38.5	33.9	31.3	27.8	25.3	20.6	16.7
9/16	0.562	84.8	80.0	76.4	72.5	65.5	61.8	53.6	50.4	43.9	40.8	35.9	33.1	29.5	26.8	21.8	17.7
19/32	0.594	89.5	84.4	80.7	76.5	69.2	65.3	56.6	53.2	46.3	43.1	37.9	35.0	31.1	28.3	23.0	18.6
5/8	0.625	94.2	88.8	84.9	80.5	72.8	68.7	59.5	55.9	48.7	45.3	39.9	36.8	32.7	29.8	24.2	19.6
21/32	0.656	98.9	93.3	89.2	84 5	76.4	72.1	62.5	58.7	51.2	47.6	41.9	38.7	34.4	31.3	25.4	20.6
11/16	0.687	103.7	97.7	93.4	88.5	80.1	75.6	65.5	61.5	53.6	49.9	43.9	40.5	36 0	32.8	26.6	21.6
23/32	0.719	108.4	102.1	97.6	92.6	83.7	79.0	68.5	64.3	56.1	52.1	45.9	42.3	37.6	34.2	27.8	22.6
3/4	0.750	113.1	106.6	101.9	96.6	87.3	82.4	71.4	67.1	58.5	54.4	48.0	44.2	39.3	35.7	29.0	23.6
25/32	0.781	117.8	111.0	106.1	100.6	91.0	85 9	74.4	69.9	60.9	56.7	50.0	46.0	40.9	37.2	30.3	24.5
13/16	0.812	122.5	115.5	110 4	104.6	94.6	89.3	77.4	72.7	63.4	58.9	52.0	47.9	42.5	38.7	31.5	25.5
27/32	0.844	127.2	119.9	114.6	108.6	98.3	92.7	80.4	75.5	65.8	61.2	54.0	49.7	44.2	40.2	32.7	26.5
7/8	0.875	131.9	124.3	118.8	112.7	101.9	96 2	83.3	78.3	68.2	63.5	56.0	51.6	45.8	41.7	33.9	27.5
29/32	0.906	136.6	128.8	123.1	116.7	105.5	99.6	86.3	81.1	70.7	65.8	58.0	53.4	47.5	43.2	35.1	28.5
15/16	0.937	141.3	133.2	127.3	120.7	109.2	103.0	89.3	83.9	73.1	68.0	60.0	55.2	49.1	44.7	36.3	29.4
31/32	0.969	146.0	137.6	131.6	124.7	112.8	106.5	92.3	86.7	75.5	70.3	62.0	57.1	50.8	46.2	37.5	30.4
1	1.000	150.7	142.1	135.8	128.7	116.4	109.9	95.2	89.5	78.0	72.6	64.0	58.9	52.4	47.7	38.7	31.4

Surface Speed of Stock

Tables II and III give surface speeds of stock varying in diameter from 1/64 to 1 inch. All the spindle speeds obtainable on the various sizes of automatic screw machines are included, except a few spindle speeds which are so near to those listed that the variation in the sur-

TABLE IV. PRINCIPAL DIMENSIONS OF AUTOMATIC SCREW MACHINES

No. of Machine	00	0	2
No. of changes of spindle speeds	12	12	12
Dia. of hole through largest feed finger	5/16″	1/2″	7/8″
Dia. of hole through feed tube	21/64″	17/32″	1 1/16″
Extreme length of feed	2″	3″	4″
Extreme length that can be turned	1 1/4″	1 3/4″	2 1/2″
No. of holes in turret	6	6	6
Dia. of holes in turret	1/2″	3/4″	1″
Dia. of turret	3 3/8″	4″	5″
Greatest length of tool that turret will swing	2 1/4″	3 1/4″	3 7/8″
Least distance bet. turret and collet face	1 5/8″	2 1/2″	2 1/8″
Greatest distance bet. turret and collet face	3″	4 1/2″	6 1/4″
Greatest dia. that turret will swing and clear turret slide	1 5/8″	2 5/8″	2 7/8″
Adjustment of turret	..	..	1″
Movement of cross-slides	1″	1 1/4″	1 3/4″
Distance from center of spindle to floor	46″	46″	46″
Floor space	22″ x 40″	23″ x 51″	26″ x 60″

face speed of the stock would be very slight. For diameters and spindle speeds not listed in the table, it will be an easy matter to find the equivalent surface speed in feet per minute by simple proportion.

In Table IV are given the principal dimensions of the Brown & Sharpe automatic screw machines. The dimensions here given will be found useful both by the operator of the machine and the designer of cams and tools for automatic screw machine work.